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ABSTRACT

This manual is one of a series of training manuals prepared for enlisted personnel in the Navy and Naval Reserve who are studying for advancement according to the Aviation Structural Mechanic E (AME) rating. The text is based on the professional qualifications for the rates AME3 and AME2. Contents include a 10-chapter text and a reading list (which includes United States Armed Forces Institute (USAFI) texts recommended as study material for AME personnel) and a subject index. Chapter headings are (1) Aviation Structural Mechanic E Rating, (2) Aeronautic Publications, (3) Handtools, Tubing, and Flexible Hose, (4) Corrosion Control, (5) Pressurization and Air-Conditioning Systems, (6) Utility Systems, (7) Gaseous Oxygen Systems, (8) Liquid Oxygen Systems, (9) Egress Systems, and (10) Line Operations and Maintenance. (HD)

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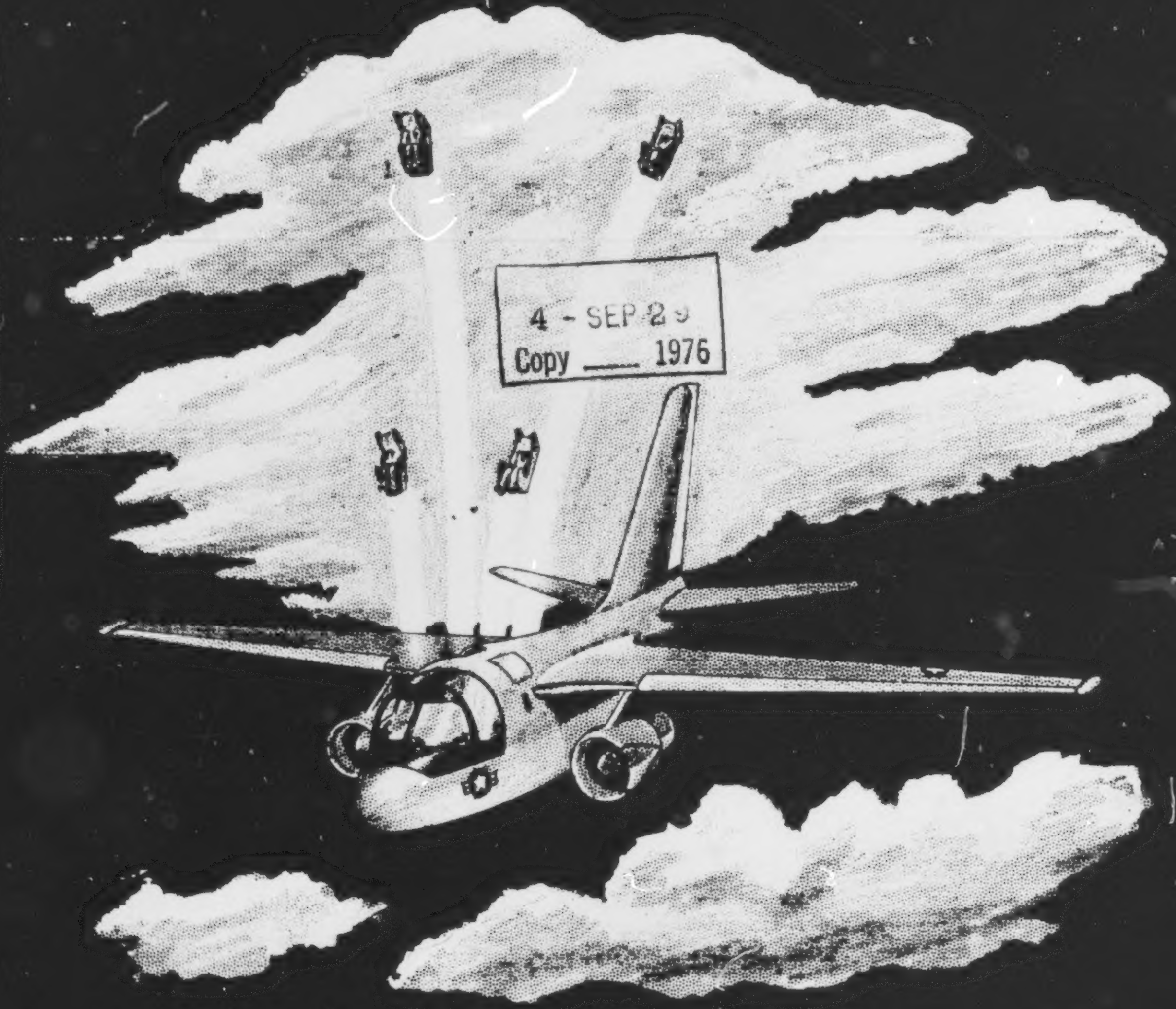

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AVIATION
STRUCTURAL MECHANIC E 3 & 2

CE 009 081

NAVAL TRAINING COMMAND

RATE TRAINING MANUAL NAVTRA 10309-C

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
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PREFACE

This Rate Training Manual is one of a series of training manuals prepared for enlisted personnel of the Navy and Naval Reserve who are studying for advancement in the Aviation Structural Mechanic E (AME) rating. As indicated by the title, the manual is based on the professional qualifications for the rates AME3 and AME2, as set forth in the Manual of Qualifications for Advancement, NavPers 18068 (Series). A reading list, which includes USAFI texts recommended as study material for AME personnel, is provided in the front of the manual.

Combined with the necessary practical experience, the completion of this manual will greatly assist the AMEAN and AME3 in preparing for advancement. This training manual should also be valuable as a review source for the more senior rates.

This training manual was prepared by the Navy Training Publications Center, NAS, Memphis, Millington, Tennessee, for the Naval Training Command. Technical review of the manuscript was provided by personnel of the AME (A) School, NAS, Memphis, Millington, Tennessee, the Naval Examining Center, Great Lakes, Illinois, and the Naval Aviation Integrated Support Center, Patuxent River, Maryland. Technical assistance was also provided by the Naval Air Systems Command.

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THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

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READING LIST

USAFI TEXTS

United States Armed Forces Institute (USAFI) courses for additional reading and study are available through your Educational Services Officer.* The following courses are recommended:

E 290 Physics I

E 291 Physics II

*"Members of the United States Armed Forces Reserve components, when on active duty, are eligible to enroll for USAFI courses, services, and materials if the orders calling them to active duty specify a period of 120 days or more."

CHAPTER 1

AVIATION STRUCTURAL MECHANIC E RATING

This training manual is designed as a self-study text for use by those personnel of the Navy and Naval Reserve who are preparing to meet the professional (technical) qualifications for advancement to petty officer third class and petty officer second class in the rating of Aviation Structural Mechanic E (Safety Equipment). Minimum professional qualifications for advancement are listed in the Manual of Qualifications for Advancement, NavPers 18068 (Series). In preparing for the advancement examination, this manual should be studied in conjunction with Military Requirements for Petty Officer 3 & 2, NavPers 10056 (Series). The latter covers the military requirements for all third and second class petty officers, as well as detailed information on the Naval Aviation Maintenance Program (NAMP).

The intent of this chapter is to provide information on the enlisted rating structure, the AME rating, requirements and procedures for advancement, and references that will help you in performing your duties as an Aviation Structural Mechanic E. This chapter also includes information on how to make the best use of Rate Training Manuals. It is therefore strongly recommended that you study this chapter carefully before beginning intensive study of the remainder of the manual.

ENLISTED RATING STRUCTURE

The present enlisted rating structure consists of general ratings and service ratings.

General ratings identify broad occupational fields of related duties and functions. Some general ratings include service ratings; others do not. Both Regular Navy and Naval Reserve personnel may hold general ratings.

Service ratings identify subdivisions or specialties within a general rating which require related patterns of aptitudes and qualifications, and which provide paths of advancement for career development. The general rating provides the primary means of identifying billet requirements and personnel qualifications; it is established or disestablished by the Secretary of the Navy; and it is provided a distinctive rating badge. The term "rate" identifies personnel occupationally by pay grade. "Rating" refers to the occupational field. Service ratings can exist at any petty officer level, but they are most common at the PO3 and PO2 levels. Both Regular Navy and Naval Reserve personnel may hold service ratings.

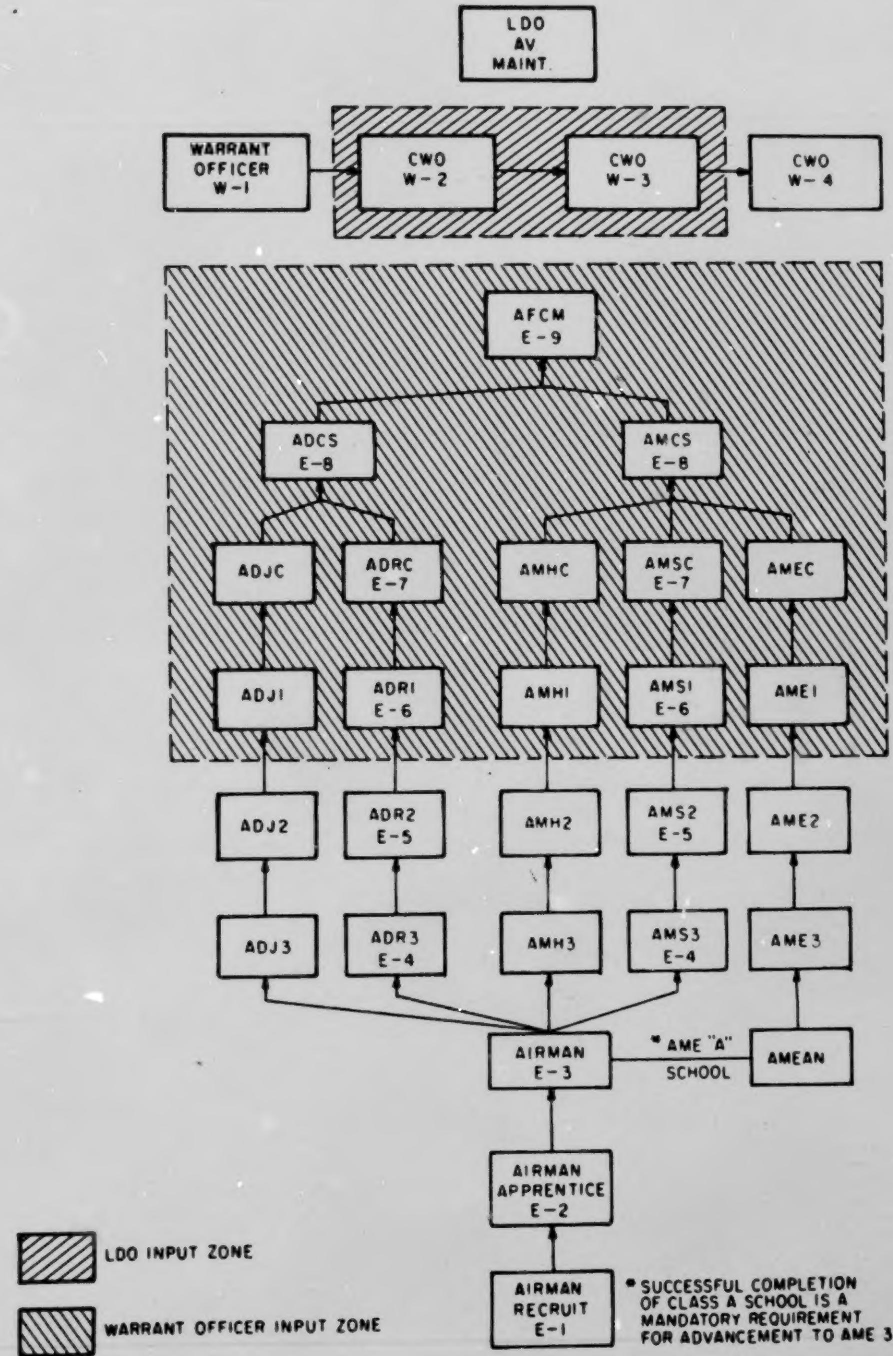
AVIATION STRUCTURAL MECHANIC (AM) RATING

The AM rating is divided into three service ratings at paygrades E-4 through E-7. The service ratings are AME (Safety Equipment), AMS (Structures), and AMH (Hydraulics).

At paygrades E-8 the general rating, AM, applies. Therefore, upon advancement to E-8, paygrade E-7 personnel (AMEC's, AMSC's, and AMHC's) are combined to become Senior Aviation Structural Mechanics (AMCS').

At paygrades E-9 the AM rating loses its identity and personnel advance, along with ADCS' to Master Chief Aircraft Maintenancemen (AFCM's).

Figure 1-1 illustrates all paths of advancement for an Airman Recruit to Master Chief Aircraft Maintenanceman, Warrant Officer (W-4), or to Limited Duty Officer. Shaded areas indicate places in the enlisted path of advancement where qualified personnel may advance to Warrant Officer (W-1) and selected Warrant Officers may advance to Limited Duty Officer. Personnel in enlisted rates and warrant ranks not in a shaded area may advance only as indicated by the lines.


LDO
AV
MAINT.
WARRANT
OFFICER
W-1
CWO
W-2
CWO
W-3
CWO
W-4
AFCM
E-9
ADCS
E-8
AMCS
E-8
ADJC
ADRC
E-7
AMHC
AMSC
E-7
AMEC
ADJ1
ADR1
E-6
AMH1
AMS1
E-6
AME1
ADJ2
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AMH2
AMS2
E-5
AME2
ADJ3
ADR3
E-4
AMH3
AMS3
E-4
AME3
AIRMAN
E-3
* AME "A"
SCHOOL
AMEAN
AIRMAN
APPRENTICE
E-2
AIRMAN
RECRUIT
E-1
LDO INPUT ZONE
WARRANT OFFICER INPUT ZONE
* SUCCESSFUL COMPLETION
OF CLASS A SCHOOL IS A
MANDATORY REQUIREMENT
FOR ADVANCEMENT TO AME 3.

AM.1

Figure 1-1.—Paths of advancement.

In view of the critical nature of the safety equipment with which the AME is concerned, present policy is that no Airman be designated an AME striker and no Airman be promoted to AME3 unless he is a graduate of the AME Class A school located at the Naval Air Technical Training Center, NAS, Memphis, Millington, Tennessee. This policy helps to insure that no unqualified personnel perform maintenance on the aircraft's life-saving gaseous and liquid oxygen systems, and that no well-meaning but untrained mechanics inspect, install, adjust or otherwise work on the ejection seat, which is so necessary to survival when needed.

In addition to the items mentioned in the foregoing paragraph, personnel in the AME rating maintain all other airborne safety equipment, including safety belts and shoulder harnesses; canopy jettison systems; life raft release and fire extinguishing systems; the air-conditioning, heating, and pressurization systems; inertia reels; anti-g systems; and visual improvement systems as well as associated lines, fittings, rigging, valves, and control mechanisms. In performing these duties the AME performs operational checks, locates troubles, removes and replaces malfunctioning components, and performs daily, preflight, postflight, and periodic inspections under the assigned AME scope.

Duty assignments available to the AME3 and AME2 are limited only by the location of operating aircraft. Billets exist on most carriers from the smallest to the largest. AME's assigned aboard carriers may be attached either to the ship or to one of the embarked squadrons. Regardless of how assigned, he will be working with other AME's assisting in keeping the aircraft flying.

AME personnel play an equally important role in patrol squadrons, which constitute a portion of the nation's anti-submarine warfare protection. By hard work and initiative, the AME may become qualified as an aircrewman in patrol type aircraft.

Many interesting overseas shore billets exist for AME's. If married, some third class and all second class petty officers may qualify to bring their dependents to these overseas locations at government expense. Shorter duty tours usually prevail at the few overseas stations where dependents are not allowed or choose not to go.

Between sea tours, the AME Third or Second Class may be assigned to one of the many naval air stations along the Gulf, East Coast, and West Coast. In addition, a few naval air stations located inland, from which aircraft are operated and AME's may be assigned.

LEADERSHIP

One does not have to be a member of the Armed Forces very long before he realizes that more leadership is required of the higher rates. Advancement not only entails the acquisition of superior knowledge, but also the demonstrated ability to handle people. This ability increases in importance as one advances through the petty officer rates.

In General Order No. 21, the Secretary of the Navy outlined some of the most important aspects of naval leadership. By naval leadership is meant the art of accomplishing the Navy's mission through people. It is the sum of those qualities of intellect, of human understanding, and of moral character that enable a man to inspire and to manage a group of people successfully. Effective leadership therefore is based on personal example, good management practices, and moral responsibility. The term leadership includes all three of these elements.

The current Navy Leadership Program is designed to keep the spirit of General Order No. 21 ever before Navy personnel. If the threefold objective is carried out effectively in every command, the program will make better leaders of men in their present and future assignments. As one advances up the leadership ladder, more and more of his worth to the Navy will be judged on the basis of the amount of efficient work obtained from his subordinates rather than how much of the actual work is performed by himself.

For further information on the practical application of leadership and supervision, the latest edition of Military Requirements for Petty Officer 3 & 2, NavPers 10056-C, should be studied. The principles and problems of naval leadership covered in NavPers 15924 (Series) and the Leadership Checklist for Petty Officers, NavPers 2932-3, will be useful tools in developing sound leadership traits.

ADVANCEMENT

Some of the rewards of advancement are easy to see. You get more pay. Your job assignments become more interesting and more challenging. You are regarded with greater respect by officers and enlisted personnel. You enjoy the satisfaction of getting ahead in your chosen Navy career.

The advantages of advancement are not yours alone. The Navy also profits. Highly trained personnel are essential to the functioning of the Navy. By advancement, you increase your value to the Navy in two ways: First, you become more valuable as a technical specialist in your own rating; and second, you become more valuable as a person who can train others and thus make far-reaching contributions to the entire Navy.

HOW TO QUALIFY FOR ADVANCEMENT

What must you do to qualify for advancement? The requirements may change from time to time, but usually you must:

1. Have a certain amount of time in your present grade.
2. Complete the required Rate Training Manuals by either demonstrating a knowledge of the material in the manual by passing a locally prepared and administered test, or by passing the Enlisted Correspondence Course based on the Rate Training Manual.
3. Utilizing an appropriate Personnel Qualification Standard (when applicable)as a guideline, become qualified and demonstrate your ability to perform all the practical requirements for advancement by completing the Record of Practical Factors, NavPers 1414/1.
4. Be recommended by your commanding officer, after the petty officers and officers supervising your work have indicated that they consider you capable of performing the duties of the next higher rate.
5. Successfully complete the applicable military/leadership examination which is required prior to participating in the advancement (professional) examination.

Some of these general requirements may be modified in certain ways. Figure 1-2 gives a more detailed view of the requirements for advancement of active duty personnel; figure 1-3 gives this information for inactive duty personnel.

Remember that the requirements for advancement can change. Check with your educational services office to be sure that you know the most recent requirements.

Advancement is not automatic. After you have met all the requirements, you are eligible for advancement. You will actually be advanced only if you meet all the requirements (including making a high enough score on the written examination) and if quotas permit.

HOW TO PREPARE FOR ADVANCEMENT

What must you do to prepare for advancement? You must study the qualifications for advancement, work on the personal qualification standard and practical factors, study the required Rate Training Manuals, and study other material that is required. You will need to be familiar with the following:

1. Manual of Qualifications for Advancement, NavPers 18068 (Series).
2. Personnel Qualification Standard for the equipment/system and rating assigned.
3. Record of Practical Factors, NavPers 1414/1.
4. Bibliography for Advancement Study, NavTra 10052 (Series).
5. Applicable Rate Training Manuals and their companion Enlisted Correspondence Courses.
6. Examinations for advancement.

Collectively, these documents make up an integrated training package tied together by the qualifications. The following paragraphs describe these materials and give some information on how each one is related to the others.

"Quals" Manual

The Manual of Qualifications for Advancement, NavPers 18068 (Series) gives the minimum requirements for advancement. This manual is usually called the "Quals" Manual, and the qualifications themselves are often called "quals". The qualifications are of two general types: military requirements, and professional (or technical) qualifications.

Military requirements apply to all ratings rather than to any one particular rating. Military requirements for advancement to third class and second class petty officer rates deal with military conduct, naval organization, military justice, security, watch standing, and other subjects which are required of petty officers in all other ratings.

REQUIREMENTS*	E1 to E2	E2 to E3	#† E3 to E4	#E4 to E5	† E5 to E6	† E6 to E7	† E7 to E8	† E8 to E9
SERVICE	4 mos. service– or completion of	8 mos. as E-2.	6 mos. as E-3	12 mos. as E-4	24 mos. as E-5.	36 mos. as E-6. 8 years total enlisted service.	36 mos. as E-7. 8 of 11 years total service must be enlisted.	24 mos. as E-8. 10 of 13 years total service must be enlisted.
SCHOOL	Recruit Training. (C.O. may advance up to 10% of graduating class.)		Class A for PR3, DT3, PT3, AME 3, HM 3, PN 3, FTB 3, MT 3.			Class B for AGC MUC, MNC. ††		
PRACTICAL FACTORS	Locally prepared check-offs.	Record of Practical Factors, NavPers 1414/1, must be completed for E-3 and all PO advancements.						
PERFORMANCE TEST			Specified ratings must complete applicable performance tests before taking examinations.					
ENLISTED PERFORMANCE EVALUATION	As used by CO when approving advancement.		Counts toward performance factor credit in advancement multiple.					
EXAMINATIONS**	Locally prepared tests.	See below.	Navy-wide examinations required for all PO advancements.				Navy-wide, selection board.	
RATE TRAINING MANUAL (INCLUDING MILITARY REQUIREMENTS)		Required for E-3 and all PO advancements unless waived because of school completion, but need not be repeated if identical course has already been completed. See NavPers 10052 (current edition).					Correspondence courses and recommended reading. See NavPers 10052 (current edition).	
AUTHORIZATION	Commanding Officer		Naval Examining Center					

* All advancements require commanding officer's recommendation.

† 1 year obligated service required for E-5, and E-6: 2 years for E-7, E-8, and E-9.

# Military leadership exam required for E-4 and E-5.

** For E-2 to E-3, NAVEXAMCEN exams or locally prepared tests may be used.

†† Waived for qualified EOD personnel.

Figure 1-2.–Active duty advancement requirements.

REQUIREMENTS *	E1 to E2	E2 to E3	E3 to E4	E4 to E5	E5 to E6	E6 to E7	E8	E9
TOTAL TIME IN GRADE	4 mos.	8 mos.	6 mos.	12 mos.	24 mos.	36 mos. with total 8 yrs service	36 mos. with total 11 yrs service	24 mos. with total 13 yrs service
TOTAL TRAINING DUTY IN GRADE †	14 days	14 days	14 days	14 days	28 days	42 days	42 days	28 days
PERFORMANCE TESTS			Specified ratings must complete applicable performance tests before taking examination.					
DRILL PARTICIPATION	Satisfactory participation as a member of a drill unit in accordance with BUPERSINST 5400.42 series.							
PRACTICAL FACTORS (INCLUDING MILITARY REQUIREMENTS)	Record of Practical Factors, NavPers 1414/1, must be completed for all advancements.							
RATE TRAINING MANUAL (INCLUDING MILITARY REQUIREMENTS)	Completion of applicable course or courses must be entered in service record.							
EXAMINATION	Standard Exam		Standard Exam required for all PO advancements. Also pass Military Leadership Exam for E-4 and E-5.				Standard Exam, Selection Board.	
AUTHORIZATION	Commanding Officer		Naval Examining Center					

*Recommendation by commanding officer required for all advancements.
† Active duty periods may be substituted for training duty.

Figure 1-3.—Inactive duty advancement requirements.

Professional qualifications are technical or professional requirements that are directly related to the work of each rating.

Both the military requirements and the professional qualifications are dividied into subject matter groups; then, within each subject matter group, they are divided into practical factors and knowledge factors. Practical factors are things you must be able to DO. Knowledge factors are things you must KNOW in order to perform the duties of your rate.

The qualifications for advancement and a bibliography of study materials are available in your educational services office. Study these qualifications and the military requirements carefully. The written examination for advancement will contain questions relating to the knowledge factors and the knowledge aspects of the practical factors of both the military requirements and the professional qualifications. If you are working for advancement to second class, remember that you may be examined on third class qualifications as well as on second class qualifications.

It is essential that the "quals" reflect current requirements of fleet and shore operations, and that new fleetwide technical, operational, and procedural developments be included. For these reasons, the qualifications are continually under evaluation. Although there is an established schedule for revisions to the "quals" for each rating, urgent changes to the "quals" may be made at any time. These revisions are issued in the form of changes to the "Quals" Manual. Therefore, never trust any set of "quals" until you have checked the change number against an up-to-date copy of the "Quals" Manual. Be sure you have the latest revision.

Personnel Qualification Standards

Personnel Qualification Standards (PQS) are presently being developed to provide guidelines in preparing for advancement and qualification to operate specific equipment and systems. They are designed to support the advancement requirements as stated in the "Quals" Manual.

The "Quals" and Record of Practical Factors are stated in broad terms. Each PQS is much more specific in its questions that lead to qualification. It provides an analysis of specific equipment and duties, assignments, or responsibilities which an individual or group of individuals (within the same rating) may be called upon to carry out. In other words, each PQS provides an analysis of the complete knowledge and skills required of that rating tied to a specific weapon system (aircraft and/or individual systems or components).

Each qualification standard has four main subdivisions in addition to an introduction and a glossary of PQS terms. They are as follows:

100 Series–Theory
200 Series–Systems
300 Series–Watchstations (duties, assignments, or responsibilities).
400 Series–Qualification cards

The introduction explains the complete use of the qualification standard in terms of what it will mean to the user as well as how to use it.

The Theory (100 Series) section specifies the theory background required as a prerequisite to the commencement of study in the specific equipment or system for which the PQS was written. These fundamentals are normally taught in the formal schools (Preparatory, Fundamentals, and Class A) phase of an individual's training. However, if the individual has not been to school, the requirements are outlined and referenced to provide guidelines for a self-study program.

The Systems (200 Series) section breaks down the equipment or systems being studied into functional sections. PQS items are essentially questions asked in clear, concise statement (question) form and arranged in a standard format. The answers to the questions must be extracted from the various maintenance manuals covering the equipment or systems for which the PQS was written. This section asks the user to explain the function of the system, to draw a simplified version of the system from memory, and to use this drawn schematic or the schematic provided in the maintenance manual while studying the system or equipment. Emphasis is given to such areas as maintenance management procedures, components, component parts, principles of operation, system interrelations, numerical values considered necessary to operation and maintenance, and safety precautions.

The Watchstation (300 series) section includes questions regarding the procedures the individual must know to operate and maintain the equipment or system. A study of the items in the 200 series section provides the individual with the required information concerning what the system or equipment does, how it does it, and other pertinent aspects of operation. In the 300 series section, the questions advance the qualification process by requiring answers or demonstrations of ability to put this knowledge to use or to cope with maintaining of the system or equipment. Areas covered include normal operation; abnormal or emergency operation; emergency procedures which could limit damage and/or casualties associated with a particular operation; operations that occur too infrequently to be considered mandatory performance items; and maintenance procedures/instructions such as checks, tests, repair, replacement, etc.

The 400 series section consists of the qualification cards. These cards are the accounting documents utilized to record the individual's satisfactory completion of items necessary for becoming qualified in duties assigned. Where the individual starts in completing a standard will depend on his assignment within an activity. The complete PQS is given to the individual being qualified so that he can utilize it at every opportunity to become fully qualified in all areas of his rating and the equipment or system for which the PQS was written. Upon transfer to a different activity, each individual must requalify. The answers to the questions asked in the qualification standards may be given orally or in writing to the supervisor, the branch or division officer, and maintenance officer as required to certify proper qualification. The completion of part or all of the PQS provides a basis for the supervising petty officer and officer to certify completion of Practical Factors for Advancement.

Record of Practical Factors

Before you can take the Navy-wide examination for advancement, there must be an entry in your service record to show that you have qualified in the practical factors of both the military requirements and the professional qualifications. A special form known as the Record of Practical Factors, NavPers 1414/1 (plus the abbreviation of the appropriate rating), is used to keep a record of your practical factor qualifications. The form lists all practical factors, both military and professional. As you demonstrate your ability to perform each practical factor, appropriate entries are made in the DATE and INITIALS columns.

Changes are made periodically to the Manual of Qualifications for Advancement and revised forms of NavPers 1414/1 are provided when necessary. Extra space is allowed on the Record of Practical Factors for entering additional practical factors as they are published in changes. The Record of Practical factors also provides space for recording demonstrated proficiency in skills which are within the general scope of the rate but which are not identified as minimum qualifications for advancement.

If you are transferred before you qualify in all practical factors, NavPers 1414/1 should be forwarded with your service record to your next duty station. You can save yourself a lot of trouble by making sure that this form is actually inserted in your service record before you are transferred. If the form is not in your service record, you will be required to start all over again and requalify in the practical factors which have already been checked off.

A second copy of the Record of Practical Factors should be made available to each man in pay grades E-2 through E-8 for his personal record and guidance.

The importance of NavPers 1414/1 cannot be overemphasized. It serves as a record to indicate to the petty officers and officers supervising your work that you have demonstrated proficiency in the performance of the indicated practical factors and is part of the criteria utilized by your commanding officer when he considers recommending you for advancement. In addition, the proficient demonstration of the applicable practical factors listed on this form can aid you in preparing for the examination for advancement. Remember that the knowledge aspects of the practical factors are covered in the examinations for advancement. Certain knowledge is required to demonstrate these practical factors and additional knowledge can be acquired during the demonstration. Knowledge factors pertain to that knowledge which is required to perform a certain job. In other words, the knowledge factors required for a certain rating depend upon the jobs (practical factors) that must be performed by personnel of that rating. Therefore, the knowledge required to proficiently demonstrate these practical factors will definitely aid you in preparing for the examination for advancement.

NavTra 10052

Bibliography for Advancement Study, NavTra 10052 (Series), is a very important publication for anyone preparing for advancement. This bibliography lists required and recommended Rate Training Manuals and other reference material to be used by personnel working for advancement. NavTra 10052 is revised and issued once each year by the Naval Training Command. Each revised edition is identified by a letter following the NavTra number. When using this publication, be sure that you have the most recent edition.

If extensive changes in qualifications occur between the annual revisions of NavTra 10052, a supplementary list of study material may be issued in the form of a Notice. When you are preparing for advancement, check to see whether changes have been made in the qualifications. If changes have been made, see if a Notice has been issued to supplement NavTra 10052.

The required and recommended references are listed by rate level in NavTra 10052. If you are working for advancement to third class, study the material that is listed for third class. If you are working for advancement to second class, study the material that is listed for second class. Remember that you are also responsible for the references listed at the third class level.

In using NavTra 10052, you will notice that some Rate Training Manuals are marked with an asterisk (*). Any manual marked in this way is MANDATORY–that is, it must be completed at the indicated rate level before you are eligible to take the Navy-wide examination for advancement. Each mandatory manual may be completed by passing the appropriate enlisted correspondence course that is based on the mandatory training manual; passing locally prepared tests based on the information given in the training manual, or in some cases, successfully completing an appropriate Class A School.

Do not overlook the section of NavTra 10052 which lists the required and recommended references relating to the military standards/requirements for advancement. For example, all personnel must complete the Rate Training Manual, Military Requirements for Petty Officer 3 & 2, NavPers 10056 (Series), for the appropriate rate level before they can be eligible to advance.

The references in NavTra 10052 which are recommended, but not mandatory, should also be studied carefully. All references listed in NavTra 10052 may be used as source material for the written examinations at the appropriate rate levels.

Rate Training Manuals

There are two general types of Rate Training Manuals. Rating manuals (such as this one) are prepared for most enlisted rates, giving information that is directly related to the professional qualifications. Basic manuals give information that applies to more than one rate and rating. Basic Electricity, NavPers 10086 (Series), is an example of a basic manual, because many ratings use it for reference.

Rate Training Manuals are produced by field activities under the management control of the Chief of Naval Training, exercised through the Naval Training Support Command. Manuals are revised from time to time to keep them up to date technically. The numbering system is being changed from NavPers to NavTra. The revision of a Rate Training Manual is identified by a letter following the NavPers or NavTra number. You can tell whether any particular copy of a Rate Training Manual is the latest edition by checking the number in the most recent edition of List of Training Manuals and Correspondence Courses, NavTra 10061 (Series). NavTra 10061 is actually a catalog that lists training manuals and correspondence courses; you will find this catalog useful in planning your study program.

Rate Training Manuals are designed to help you prepare for advancement. The following suggestions may help you to make the best use of this manual and other Navy training publications when you are preparing for advancement.

1. Study the military requirements and the professional qualifications for your rate before you study the training manual, and refer to the "quals" frequently as you study. Remember, you are studying the training manual in order to meet these "quals."

2. Set up a regular study plan. If possible, scheduled your studying for a time of day when you will not have too many interruptions or distractions.

3. Before you begin to study any part of the training manual intensively, become familiar with the entire manual. Read the preface and the table of contents. Check through the index. Look at the appendixes. Thumb through the manual without any particular plan, looking at the illustrations and reading bits here and there as you see things that interest you.

4. Look at the training manual in more detail, to see how it is organized. Look at the table of contents again. Then, chapter by chapter, read the introduction, the headings, and the

subheadings. This will give you a clear picture of the scope and content of the manual. As you look through the manual in this way, ask yourself some questions: What do I need to learn about this? What do I already know about this? How is this information related to information given in other chapters? How is this information related to the qualifications for advancement?

5. When you have a general idea of what is in the training manual and how it is organized, fill in the details by intensive study. In each study period, try to cover a complete unit—it may be a chapter, a section of a chapter, or a subsection. If you know the subject well, or if the material is easy, you can cover quite a lot at one time. Difficult or unfamiliar material will require more study time.

6. In studying any one unit—chapter, section, or subsection—write down the questions that occur to you. Many people find it helpful to make a written outline of the unit as they study, or at least to write down the most important ideas.

7. As you study, relate the information in the training manual to the knowledge you already have. When you read about a process, a skill, or a situation, try to see how this information ties in with your own past experience.

8. When you have finished studying a unit, take time out to see what you have learned. Look back over your notes and questions. Maybe some of your questions have been answered, but perhaps you still have some that are not answered. Without referring to the training manual, write down the main ideas that you have learned from studying this unit. Do not quote the manual. If you cannot give these ideas in your own words, the chances are that you have not really mastered the information.

9. Use Enlisted Correspondence Courses whenever you can. The correspondence courses are based on Rate Training Manuals or on other appropriate texts. As mentioned before, completion of a mandatory Rate Training Manual can be accomplished by passing an Enlisted Correspondence Course based on the Rate Training Manual. You will probably find it helpful to take other correspondence courses, as well as those based on mandatory training manuals. Taking a correspondence course helps you to master the information given in the training manual, and also helps you see how much you have learned.

10. Think of your future as you study Rate Training Manuals. You are working for advancement to third class or second class right now, but someday you will be working toward higher rates. Anything extra that you can learn now will help you.

SOURCES OF INFORMATION

One of the most useful things you can learn about a subject is how to find out more about it. No single publication can give you all the information you need to perform the duties of your rating. You should learn where to look for accurate, authoritative, up-to-date information on all subjects related to the military requirements for advancement and the professional qualifications of your rating.

Some of the publications described in this manual are subject to change or revision from time to time—some at regular intervals, others as the need arises. When using any publication that is subject to change or revision, be sure that you have the latest edition. When using any publication that is kept current by means of changes, be sure you have a copy in which all official changes have been made. Studying canceled or obsolete information will not help you perform efficiently or to advance; it is likely to be a waste of time, and may even be seriously misleading.

Some publications that you will need to study or refer to as you prepare for advancement have already been discussed earlier in this chapter. Additional publications that you may find useful are as follows:

Tools and Their Uses, NavPers 10085-B.

Blueprint Reading and Sketching, NavPers 10077-C.

Basic Electricity, NavPers 10086-B (Chapters 1, 2, and 4).

Fluid Power, NavPers 16193-B.

In addition, you may find it useful to consult some of the Rate Training Manuals prepared for other Group IX (Aviation) ratings. Reference to these Rate Training Manuals will add to your knowledge of the duties of other personnel in the field of aviation.

Naval Air Systems Command (NavAir) publications of significant interest to the AME are discussed in chapter 2 of this manual.

Training films available to naval personnel are also a valuable source of information on many technical subjects. These films are listed in the United States Navy Film Catalog, NavAir 10-1-777, and supplements.

CHAPTER 2

AERONAUTIC PUBLICATIONS

Aeronautic publications are issued by authority of the Commander of the Naval Air Systems Command. These publications are the sources of information for guiding naval personnel in the operation and maintenance of all aircraft and related equipment within the Naval Establishment. By proper use of these publications, all aircraft and other aeronautic equipment can be operated and maintained efficiently and uniformly throughout the Navy.

Aeronautic publications may be grouped into two major classes or groups—those issued in the form of MANUALS, and those issued in the form of LETTER MATERIAL.

When a new aircraft, engine, accessory, or other item of equipment is accepted by the Navy, manuals necessary to insure its proper operation and upkeep are prepared and issued to all activities using and/or maintaining the equipment. Supplemental information and other directive type publications that must be issued from time to time are issued in the form of letter material. Both manual and letter publications may, on occasion, be properly referred to as directives. Broadly speaking, any communication which initiates or governs action, conduct, or procedure is a directive.

All aeronautic publications, both manual and letter type, are assigned a title and code number. When they are available for issue, all publications, except Instructions and Notices, are listed in the Naval Aeronautic Publications Index.

NAVAL AERONAUTIC PUBLICATIONS INDEX

The Naval Aeronautic Publications Index is made up of six parts, each of which serves a specific purpose. They are identified as follows:

Airborne Weapons/Stores, Conventional/Nuclear, Checklists/Stores Reliability Cards/Manual, NavAir 01-700. This part of the publications index is not used by AME personnel and therefore is given no further coverage in this chapter.

Navy Stock List of Forms and Publications, NavSup Publication 2002, Section VIII, Parts C and D, Numerical Sequence List (also referred to as Numerical Index).

Equipment Applicability List (Volumes 1 through 7), NavAir 00-500A.

Aircraft Application List, NavAir 00-500B.

Directives Application List, NavAir 00-500C.

Letter Type Technical Directives Equipment and Subject Application List, NavAir 00-500D.

A description of these lists and their uses is presented in the following paragraphs.

NUMERICAL SEQUENCE LIST

NavSup Publication 2002 is a 13-section index of all the forms and publications used throughout the Navy and stocked by the Naval Supply Systems Command. Section VIII of this Stock List contains Naval Air Systems Command (NavAirSysCom) publications. This section is made up of four parts—A, B, C, and D. Parts A and B pertain to ordnance publications. Part C is the numerical listing of manual type aeronautic technical publications, and Part D is the numerical listing of letter type publications. These two, Parts C and D, are referred to as the Numerical Sequence List or Numerical Index of the Naval Aeronautic Publications Index.

Part C (manual publications) contains its table of contents, as well as the instructions for using both Parts C and D of NavSup Publication 2002. Included in these instructions are the method for procuring aeronautic publications, the forms and procedures required for ordering publications, and explanations of certain codes used in the Index. Also a listing of canceled publications for Part C is contained in the last pages of Part C.

Part C is divided into subject matter groups, and all publications within a group are then listed in numerical order. For example, all manuals in the 00 series are listed first, then followed by the 01, 02, 03, etc., through the 51 series. The listing includes the publication code number, stock number, title, date of latest issue or revision, security classification, requisition restriction code, and basic or change code. A listing of the general subject groups is shown in table 2-1.

Part D (letter type directives) contains a table of contents, a general alphabetical cross-reference listing, and a listing of Air Force-Navy code cross-references.

Table 2-1.—General subject classification numbers for manual type publications.

General	.00
Aircraft	.01
Powerplants (02A reciprocating engines, 02B jet engines, 02F rocket engines)	.02
Accessories	.03
Hardware and Rubber Material	.04
Instruments	.05
Fuels, Lubricants, and Gases	.06
Dopes and Paints	.07
Electronics	08 & 16
Instructional Equipment and Training Aids	09 & 28
Photography	.10
Aviation Armament	.11
Fuel and Oil Handling Equipment	.12
Parachute and Personal Survival Equipment	.13
Hangers and Flying Field Equipment	.14
Standard Preservation and Packaging Instructions	.15
Machinery, Tools, and Test Equipment	17 & 18
Ground Servicing and Automotive Equipment	.19
Descriptive Data Sheets for Aviation Support Equipment (Being superseded by Ground Support Equipment Illustrations (GSEI))	.20
Chemical Equipment	24 & 39
Meteorology	.50
Ship Installations	.51

Part D is divided into a number of subsections. Included among those of interest to the AME are general, aircraft, accessories, and support equipment. Listed in the general section are Aircrew System Bulletins and Changes, Aviation Clothing and Survival Equipment Bulletins and Changes, Technical Orders, and Technical Notes. In the aircraft section are listed all Aircraft Changes and Bulletins. The accessories section contains a listing of all Accessories Changes and Bulletins. The support equipment section contains a listing of all Support Equipment Changes and Bulletins.

The Numerical Index must be used to completely identify and, therefore, to order required publications. However, the other parts of the Index (discussed in the following paragraphs) must be used to determine what publications are available for a specific item of equipment and to check the applicability of publications to specific equipment.

When an applicable publication number is found in one of the other parts of the Naval Aeronautic Publications Index, it can be easily located in the Numerical Index. Here, it can be more completely identified as to title and nomenclature, stock number (for manual type publications), security classification, and any restrictions concerning the requisitioning of the publication. In addition, the date of the latest issue or revision of the publication is listed. This provides a means whereby the issue and/or revision dates of the publications on hand in an activity can be checked against the dates listed in the current issue and supplement (discussed later) of the Numerical Index, thus assuring that the publications are current.

EQUIPMENT APPLICABILITY LIST

Basically, the Equipment Applicability List, NavAir 00-500A, is a cross-reference index listing of Naval Air Systems Command (NavAirSysCom) publications of aircraft components and related equipment according to model, type, or part number.

Since this index contains several thousand entries, one volume would be very cumbersome to use. For this reason, this index is divided into several volumes. At the time of this writing, there are seven volumes.

With the exception of several small sections in the first part of Volume 1, the Equipment Applicability List is one continuous index of model, type, or part numbers in alphanumerical sequence.

In addition to an Introduction, which explains the headings at the top of each page, the other sections in the first part of Volume 1 pertain primarily to manuals for aircraft, weapons systems, and aircraft engines. Therefore, the publication numbers are listed according to aircraft, aircraft engine, and weapons system designation.

The Equipment Applicability List should be used when attempting to determine what publications are available on a particular item of equipment, and the manufacturer and part number of the item are known.

AIRCRAFT APPLICATION LIST

The Aircraft Application List, NavAir 00-500B, contains a listing of all manuals grouped according to their application to an aircraft. This part of the index does not contain listings of any letter type publications, and all manuals are listed by publication code number only.

A list of basic numbering categories is provided in the front of the book. This list may be used in determining the general type of equipment covered in a publication. For determining the specific item of equipment covered by a publication and the title of the publication, reference should be made to Part C of Section VIII in NavSup Publication 2002.

The Aircraft Application List is especially handy for determining what manuals are available for a particular model of aircraft. Included under each model is a complete listing of applicable manuals. This listing includes all allowance lists, aircraft manuals, engine manuals, accessories manuals, etc., pertaining to that particular model of aircraft.

DIRECTIVES APPLICATION LIST BY AIRCRAFT CONFIGURATION

The Directives Application List by Aircraft Configuration, NavAir 00-500C, contains a listing of the active Naval Air Systems Command letter type technical directives with respect to their applicability to aircraft. The lists in this volume are arranged first by aircraft series, second by aircraft configuration, and third by Airframe/Aircraft Bulletin and/or Change numbers. NOTE: Configuration refers to modifications made to a basic aircraft model. For instance, A-4A, A-4B, TA-4F, etc., are all different configurations of the A-4 aircraft model.

EQUIPMENT AND SUBJECT APPLICABILITY LIST

The Equipment and Subject Applicability List, NavAir 00-500D, is a relatively recent addition to the Naval Aeronautic Publications Index. It contains a cross-reference index listing of Naval Air Systems Command letter type technical directives. It serves the same purpose for letter type technical directives as the Equipment Applicability List, NavAir 00-500A, does for technical manuals. However, since the NavAir 00-500D lists only those model/type part numbers for which technical directives have been issued, it is much smaller than the NavAir 00-500A. The complete List is contained in one volume but is divided into two parts. Part A is the Equipment Index and Part B is the Subject Index.

Part A contains a listing of all Naval Air Systems Command letter type technical directives on aircraft components and related equipment by model/type part number. Each number is listed in alphanumerical sequence within its cognizant equipment series. At the present time, Part A is divided into nine series. The Accessories, Aircrew Systems, and Clothing and Survival Equipment Series are of most interest to AM personnel.

Part B of NavAir 00-500D contains a listing of active Naval Air Systems Command letter type directives by subject. This part of the List pertains primarily to Airframe Bulletins and Changes.

UPDATING THE INDEX

Each List in the Naval Aeronautic Publications Index is updated at regular intervals by the issuance of a new list. In addition, some of these Lists are kept current by the periodic issuance of supplements between issues of the Basic List. The dates and intervals of the issuance of new Lists and supplements have changed from time to time in the past.

At the time of this writing, the Numerical Index (Parts C and D of NavSup Publication 2002) is issued annually in September. Supplements are issued bimonthly between each basic issue. The Equipment Applicability List, NavAir 00-500A, is issued annually in November. This List is kept current by the issuance of quarterly supplements between each basic issue. The Aircraft Application List, NavAir 00-500B, is issued in March and September, and the Directives

Application List by Aircraft Configuration, NavAir 00-500C, is issued in January and July of each year. Supplements are not issued for these Lists.

The Equipment and Subject Application List, NavAir 00-500D, is issued in May and November of each year, and as of this writing, supplements will be issued as the information is developed.

Supplements list all aeronautic publications distributed during the previous period, and those publications that have been superseded, canceled, or revised. Supplements are cumulative, that is, all material from the preceding supplement is incorporated in the latest supplement; therefore, at any given time, not more than one supplement is in effect for any List. Naturally, the reissue of a basic List cancels the outstanding supplement.

Supplements for the Numerical Index (Parts C and D of Section VIII of NavSup Publications 2002) are identified by the word "supplement" printed near the upper right-hand corner of the cover. Supplements to the NavAir 00-500A Series publications are identified by the word "supplement" printed in the middle of the cover page.

PUBLICATIONS NUMBERING SYSTEM

Code numbers are assigned to all publications in order that they may be identified, indexed, and filed. A knowledge of the numbering systems used will enable the AME to locate any desired information with a minimum of effort. A brief explanation of the coding of manuals listed in the index is given in the following sections. Coding for letter type material is covered later in this chapter.

Code numbers assigned to manuals consist of a prefix and a series of three parts. The prefix consists of letters which identify the originator of the publication.

NavAir is the prefix assigned to technical publications originated by the Naval Air Systems Command. In the stock list, it is shortened to NA.

The three parts which make up the remaining portions of the number indicate the following:

Part I is a two-digit number that indicates the general subject classification of the equipment covered by the publication. Table 2-1 lists the general subject categories and the appropriate two-digit numbers.

Part II of the publications code number consists of numbers and/or numbers and letters and indicates the specific class, group, type, or model and manufacturer of the equipment. The subject breakdowns are listed at the beginning of each separate major division within the Numerical Index.

Part III consists of a number or numbers which designate a specific manual. For aircraft and powerplants, this number designates a specific type of manual. For other types of equipment, this part is assigned in numerical sequence and has no reference to the type of manual.

Figure 2-1 illustrates the identification and decoding of a complete manual publication number.

SECURITY OF CLASSIFIED PUBLICATIONS

The Department of the Navy Security Manual for Classified Information (OpNav Instruction 5510.1 Series), issued by the Chief of Naval Operations, is the basic security directive relating to safeguarding classified information. Its provisions apply to all military and civilian personnel and to all activities of the Naval Establishment.

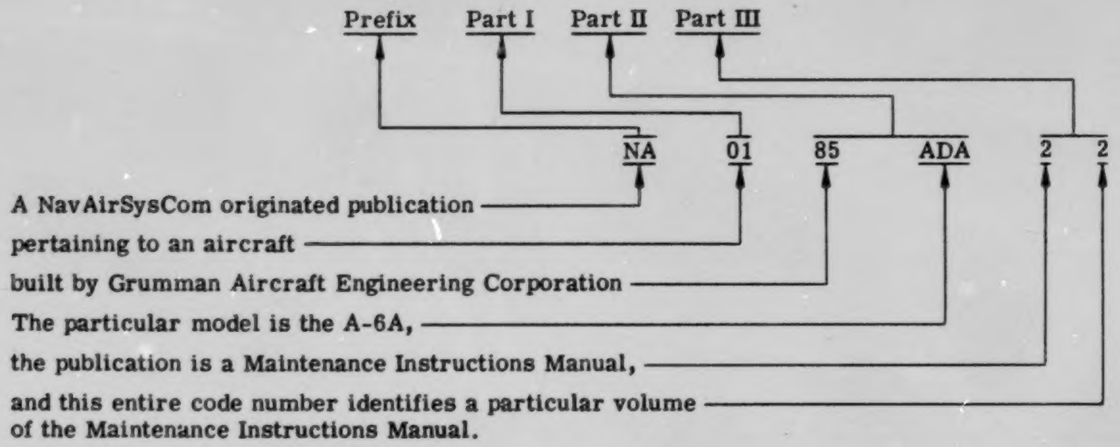
The manual contains detailed instructions for classifying, marking, and handling classified information, and for access to and authorized disclosure of the information.

The AME, from time to time, has occasion to use classified publications relating to the performance of his work. Before he accepts such publications he must be cleared to the appropriate degree to handle this classified matter. It is then mandatory that he have knowledge of and abide by the instructions in the Security Manual pertaining to handling classified material.

Publications listed in the Numerical Index (Parts C and D of Section VIII of NavSup Publication 2002) are unclassified unless otherwise marked "1" (confidential) or "4" (secret) in the column headed PS (physical security). The Index is not classification authority. The supplements to the Index contain information of classification action on "when-occurring" basis.

MANUAL TYPE PUBLICATIONS

To attain a satisfactory state of readiness, technical manuals are developed, published, and distributed concurrently with the weapon system or equipment that they cover. Periodic changes and revisions are issued as necessary to insure that manuals continually reflect equipment


Prefix
Part I
Part II
Part III
NA
01
85
ADA
2
2
A NavAirSysCom originated publication
pertaining to an aircraft
built by Grumman Aircraft Engineering Corporation
The particular model is the A-6A,
the publication is a Maintenance Instructions Manual,
and this entire code number identifies a particular volume of the Maintenance Instructions Manual.

AM.176

Figure 2-1.—Identification and decoding of manual publication code number.

changes and current operational and support concepts and procedures.

The Rapid Action Change (RAC) System provides a quick response capability for the delivery of urgently required technical information. Under this system, information affecting flight safety, hazards to personnel, or grounding of aircraft is disseminated via naval message and immediately incorporated into the affected manual. A manual change page followup is then required within 15 days of the release of the message. Information of a less urgent nature is disseminated by RAC change pages that must be printed within 30 days after problem resolution and is generally limited to 12 pages or less.

The RAC System for manual changes replaces the previous Interim Manual Change System but does not affect the normal manual change and revision requirements. It merely supplements the existing Normal Change System to provide for rapid issue of urgently required data which previously was not available to the user for long periods of time due to system red tape, such as routing and printing delays.

As shown in table 2-1, manuals are published in a number of different general subject categories. Those of special interest to the AME3 and AME2 are the General Manuals (00 series), Aircraft Manuals (01 series), and the Accessories Manuals (03 series). Certain manuals in other series may be used occasionally, but those listed here are of special importance to the Aviation Structural Mechanic.

GENERAL MANUALS (00 SERIES)

As indicated by the title, this series of manuals includes information of interest to all naval aviation personnel. Included are four parts of the Naval Aeronautic Publications Index (00-500A, 00-500B, 00-500C, and 00-500D, already described), NavAir Outfitting Lists and Allowance Lists, and Aviation Training Literature.

Allowance Lists and Outfitting Lists (00-35Q Series)

Allowance Lists and Outfitting Lists consist of listings of the equipment and material necessary to place and maintain various activities in a material readiness condition. These allowances are based on known or estimated requirements or on available usage data.

Allowance Lists are identified by SECTIONS. Certain sections such as A, H, and K are issued as individual publications. Others such as B and R appear as a series of publications, each of which is applicable to a specific model of equipment, model of aircraft, or type of activity.

The AME should be familiar with the following sections:

Section A, Standard Aeronautical and Navy Stock Account Material.

Section B, Airframe and Engine Maintenance Parts. This section contains the initial outfitting list for each model of aircraft in current use.

Section G, General Support Equipment. This section lists all consumable general support equipment for all classes, types, and models of aircraft.

Section H, Flight Operational Material for Aircraft Squadrons. This section lists aviator's flight clothing as well as the protective clothing available for use when handling liquid oxygen.

Section K, Allowance List for Naval Aeronautic Publications and Forms.

Allowance Lists are reissued periodically. When new issues or reissues are published, they are listed in the next issue of the Numerical Index. All lists not appearing in the current issue of the Numerical Index or latest supplement have been canceled.

All allowance List and Outfitting List code numbers are NA 00-35Q plus the section identification letter and a dash number to identify a particular section in a series. For example, the Section B Allowance List for the S-2D aircraft is NA 00-35QB-177. This publication contains the initial outfitting list for the S-2D aircraft.

Training Literature (00-80 Series)

This series of publications is issued by authority of the Deputy Chief of Naval Operations (Air). Included are various Air Safety Pamphlets and General Aviation Training Publications. All such publications listed in the current issue of the Numerical Index are available at the various NavAir Publications Supply Points. All requests for 50 or more copies of a publication must be submitted to the Chief of Naval Operations, Flight Training Branch, Washington, D.C., with a statement of justification.

AIRCRAFT MANUALS (01 SERIES)

The following types of manuals are prepared and issued for each model of aircraft used by the Navy:

NATOPS Flight Manual.
Maintenance Instructions Manual.
Structural Repair Manual.
Periodic Maintenance Requirements Manual or Periodic Maintenance Information Cards.
Illustrated Parts Breakdown.
Technical Manual of Weight and Balance Data (certain aircraft only).

NATOPS Flight Manual

The NATOPS (Naval Air Training and Operating Procedures) Flight Manual contains complete operating instructions for the aircraft and its operational equipment. Emergency operating instructions as well as normal operating instructions are provided. Although NATOPS Flight Manuals are issued primarily for the use of pilots and aircrewmen, all maintenance personnel should become familiar with the contents of the Flight Manual for their respective aircraft.

NATOPS Flight Manuals are kept up to date by two types of revisions—regular revisions and interim revisions. Regular revisions cover routine changes and instructions and are generally issued every 90 days. Interim revisions cover vital operating instructions and are used when immediate action is necessary. Interim revisions may be issued in letter form to the individual activities and by naval message to commands, and are later incorporated as regular revisions.

Maintenance Instructions Manuals

The Maintenance Instructions Manuals (MIM's) contain all the essential information required by aircraft maintenance personnel for service and maintenance of the complete aircraft. MIM's include the data necessary for troubleshooting and maintaining the powerplant, accessories, and all other systems and components of the aircraft.

Maintenance Instructions Manual are divided into three types. Type I manuals contain all essential information required for performing Organizational level maintenance, such as description and operation of systems and components, maintenance considerations, and appropriate diagrams and schematics.

Type II manuals contain Intermediate level maintenance instructions required for the maintenance of components, systems, groups of systems, or equipment when separate coverage is not provided in other manuals. Included are procedures for checkout, troubleshooting, repair, replacement, adjustment, calibration, and preinstallation, and/or shipping information (method of packaging). Coverage on components or equipment may include a description of component operation if it is not covered in the Type I manual.

Type III manuals contain Depot level overhaul and repair instructions for components, accessories, and any other equipment necessary for unit operation.

In many cases, a consolidation of any combination of Types I, II, or III manuals is provided in one manual. This is the type discussed in the following paragraphs and most common to the AME.

The Maintenance Instructions Manual for all current production aircraft is made up in volumes, each volume being individually bound and issued separately. This permits each shop in an activity to have its own applicable volume, or volumes, at hand for ready reference. Volumes of most interest to the AME are as follows:

General Information and Servicing.
Utility Systems.
Survival and Environmental Systems.
Corrosion Control, Cleaning, Painting, and Decontamination.

NOTE: The different aircraft manufacturers may group the material in the various volumes of the Maintenance Instructions Manuals under different titles. For example, the Survival and Environmental Systems volume for the RA-5C covers the ejection seat, canopy, liquid oxygen, heating, air-conditioning, ventilation, and anti-g systems. Two volumes, titled Personnel Environmental Systems and Canopy and Survival Systems, are prepared to cover the same subjects for the A-4 aircraft.

The General Information and Servicing volume is designed primarily for the plane captain; however, this volume also contains a great deal of information important to all AME personnel. This volume contains a general description of the aircraft, all necessary information which is not contained in other specialized manuals, and all information pertaining to servicing the air craft.

Each of the specialized system volumes of the Maintenance Instructions Manual is further divided into four sections, as described in the following paragraphs.

Section I is the same in all volumes of a particular aircraft Maintenance Instructions Manual. This section provides an introduction to the manual and usually supplies a list of the Changes applicable to the particular volume concerned.

Section II describes the system and components as well as their operation.

Section III provides such maintenance coverage as removal and installation procedures and troubleshooting charts for Organizational level of maintenance.

Section IV provides component repair procedures for the Intermediate level of maintenance.

Figure 2-2 is an example of a page from section III of a Maintenance Instructions Manual. This page shows the basic layout of the maintenance-coverage sections of the specialized type manuals. Each component maintenance procedure is identified by a boldface heading (item A, fig. 2-2) for ease in locating the material on the page. All removal and installation procedures provide a recommended manpower requirement (item B) for the shop chief's use in assigning personnel to perform the job. All tools and equipment other than standard tools are noted (item C) ahead of the maintenance procedure, so that these items may be drawn from the toolroom prior to starting the operation.

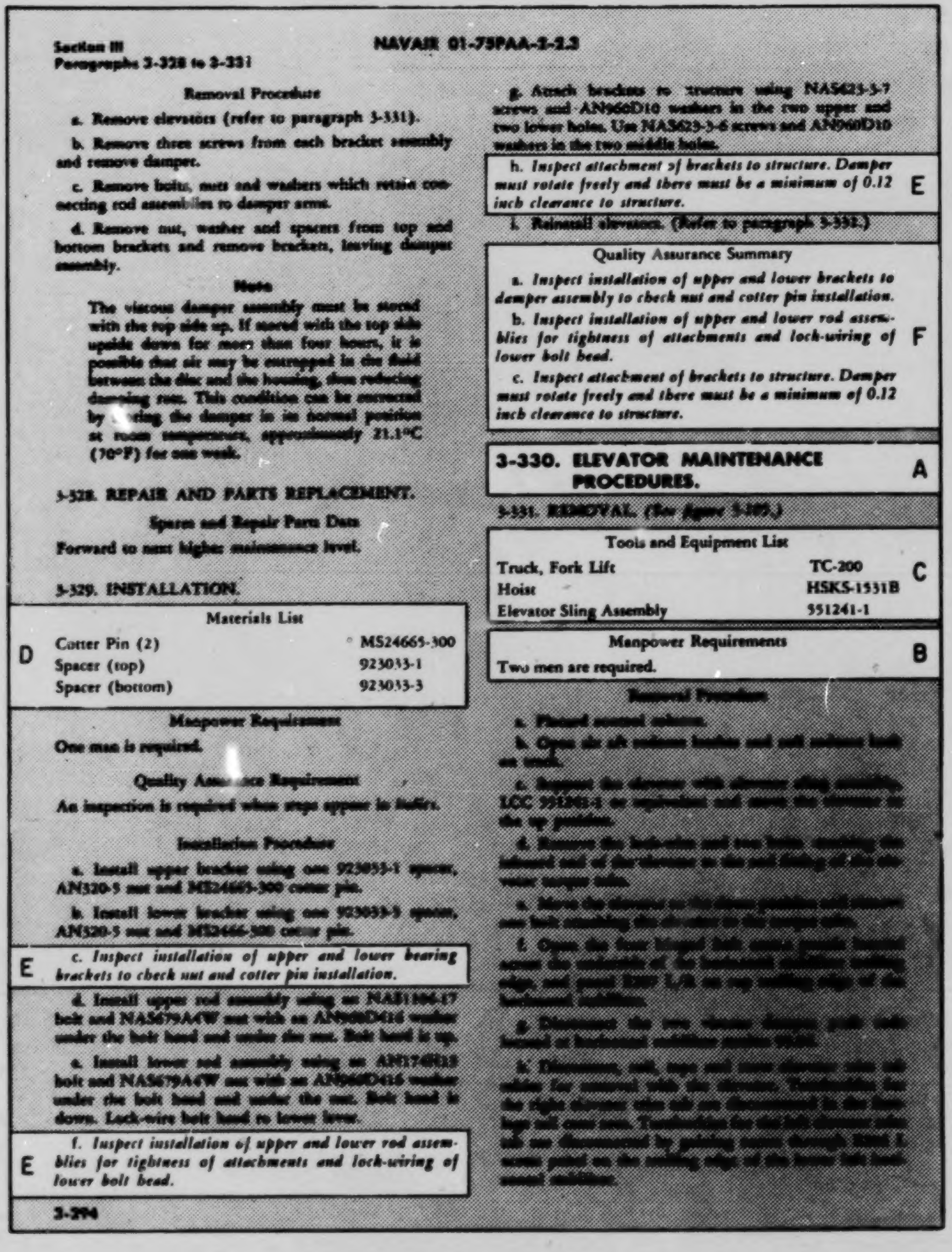
When consumable materials such as lubricants, lockwire, and cotter pins are required during an installation procedure, a listing of these (item D) is made ahead of the procedural steps. Miscellaneous small parts (other than standard AN and MS hardware), which are necessary for removal and an installation, also appear in the materials list.

As an aid to Quality Assurance Representatives, those steps in a procedure which require an inspection are set in italics (items marked E). (NOTE: In some MIM's the steps in a procedure which require a Quality Assurance inspection are underlined.) These italicized steps are a very important feature and are summarized (item F) at the end of each procedure.

Classified maintenance information is not included in the regular volumes of the Maintenance Instructions Manual. Essential classified information is contained in separate volumes or supplements of the Maintenance Instructions Manual, which are classified "confidential." Classified volumes of the Maintenance Instructions Manual are bound in red in order that they may be readily identified. These volumes must be handled in accordance with the Department of the Navy Security Manual for Classified Information (OpNav Instruction 5510.1 Series).

Structural Repair Manual

The Structural Repair Manual is used as a guide in making structural repairs to the



Section III
Paragraphs 3-328 to 3-331

NAVAIR 01-75PAA-2-2.3

Removal Procedure

a. Remove elevators (refer to paragraph 3-331).

b. Remove three screws from each bracket assembly and remove damper.

c. Remove bolts, nuts and washers which retain connecting rod assemblies to damper arms.

d. Remove nut, washer and spacers from top and bottom brackets and remove brackets, leaving damper assembly.

Note

> The viscous damper assembly must be stored with the top side up. If stored with the top side upside down for more than four hours, it is possible that air may be entrapped in the fluid between the disc and the housing, thus reducing damping rate. This condition can be corrected by storing the damper in its normal position at room temperature, approximately 21.1°C (70°F) for one week.

3-328. REPAIR AND PARTS REPLACEMENT.

Spares and Repair Parts Data

Forward to next higher maintenance level.

3-329. INSTALLATION.

Materials List

Cotter Pin (2)	MS24665-300
Spacer (top)	923033-1
Spacer (bottom)	923033-3

Manpower Requirements

One man is required.

Quality Assurance Requirement

An inspection is required when steps appear in italics.

Installation Procedure

a. Install upper bracket using one 923033-1 spacer, AN320-5 nut and MS24665-300 cotter pin.

b. Install lower bracket using one 923033-3 spacer, AN320-5 nut and MS2466-300 cotter pin.

c. Inspect installation of upper and lower bearing brackets to check nut and cotter pin installation.

d. Install upper rod assembly using an NAS1106-17 bolt and NAS679A4W nut with an AN960D416 washer under the bolt head and under the nut. Bolt head is up.

e. Install lower rod assembly using an AN174H13 bolt and NAS679A4W nut with an AN960D416 washer under the bolt head and under the nut. Bolt head is down. Lock-wire bolt head to lower lever.

f. Inspect installation of upper and lower rod assemblies for tightness of attachments and lock-wiring of lower bolt head.

g. Attach brackets to structure using NAS623-3-7 screws and AN960D10 washers in the two upper and two lower holes. Use NAS623-3-6 screws and AN960D10 washers in the two middle holes.

h. Inspect attachment of brackets to structure. Damper must rotate freely and there must be a minimum of 0.12 inch clearance to structure.

i. Reinstall elevators. (Refer to paragraph 3-332.)

Quality Assurance Summary

a. Inspect installation of upper and lower brackets to damper assembly to check nut and cotter pin installation.

b. Inspect installation of upper and lower rod assemblies for tightness of attachments and lock-wiring of lower bolt head.

c. Inspect attachment of brackets to structure. Damper must rotate freely and there must be a minimum of 0.12 inch clearance to structure.

3-330. ELEVATOR MAINTENANCE PROCEDURES.

3-331. REMOVAL. (See figure 3-105.)

Tools and Equipment List

Truck, Fork Lift	TC-200
Hoist	HSKS-1531B
Elevator Sling Assembly	551241-1

Manpower Requirements

Two men are required.

Removal Procedure

a. Placard control column.

b. [illegible]

c. [illegible] LCC 551241-1 or equivalent and [illegible] the up position.

d. [illegible]

e. [illegible]

f. [illegible]

g. [illegible]

h. [illegible]

3-294

Figure 2-2.—Typical page of a Maintenance Instructions Manual.

AM. 225

airframe. It contains general information such as airframe sealing, control surface rebalancing, general shop practices, damage evaluation and support of structure, and a description of the structure through the medium of indexed illustrations and repair drawings.

The Structural Repair Manual for most new aircraft is published in two volumes. This is not due to its size but is to suit its usage by different facilities. Volume I is for use at all levels of maintenance. Volume II supplements Volume I and contains information for use at Intermediate and Depot level facilities.

The Structural Repair Manual is identified by a "-3" in the manual publications code (fig. 2-1). The two volumes are further identified by an additional dash number. An example of the code for a Structural Repair Manual in current use is NA 01-75PAA-3-1. This is the code for Volume I of the Structural Repair Manual for the P-3A aircraft.

Each volume of the Structural Repair Manual is divided into sections. Section I contains information of a general nature. Each of the other sections contains information of a more specific nature. These sections cover portions of the aircraft such as wings, tail, fuselage, alighting gear, and engines. There is also a section covering typical repairs.

Before attempting to use the Structural Repair Manual, the mechanic should read the introduction to Volume I. Included in the introduction is information concerning the use of the manual. NOTE: Since the format of the various Structural Repair Manuals may differ, the instructions in the introduction may differ slightly.

The Structural Repair Manual is supplemented by the NA 01-1A Series general manuals.

Periodic Maintenance Requirements Manual

This manual contains the complete requirements for inspection of the aircraft, its components, and accessories. The inspection requirements are stated in such a manner as to establish what equipment is to be inspected, when it is to be inspected, and what conditions are to be sought. It does not contain instructions for repair, adjustment, or other means of correcting defective conditions, nor does it contain instructions for troubleshooting to find causes for malfunctioning.

Periodic Maintenance Requirements Data

The Periodic Maintenance Requirements Manuals are being replaced by periodic maintenance requirements data contained in three types of publications--Periodic Maintenance Information Cards (PMIC), Maintenance Requirements Cards (MRC), and Sequence Control Charts (SCC).

The PMIC's have a listing of items having an approved mandatory replacement interval and those items requiring scheduled removal component cards as defined in OpNav Instruction 4790.2.

They also contain a maintenance reference table that lists those publications which have been incorporated in the maintenance requirements since the last revision.

The Maintenance Requirements Cards and the Sequence Control Chart are discussed in Military Requirements for Petty Officer 3 &2, NavPers 10056-C, Chapter 14.

Illustrated Parts Breakdown

The purpose of the Illustrated Parts Breakdown (IPB) is to assist supply, maintenance, and overhaul personnel in the identification, requisitioning, storing, and issuing of parts for the applicable aircraft.

The IPB for older aircraft, like the Maintenance Instructions Manual, may be found in one volume. The IPB prepared for current production aircraft contains several volumes, which usually correspond to the volumes in the Maintenance Instructions Manual.

The IPB, like the Maintenance Instructions Manual, has a code number. A "-4" in part III of the publications code (fig. 2-1) identifies the IPB. The individual volumes of the IPB are identified by an additional dash and number. An example of the code number for an IPB in current use is NA 01-60ABC-4-5. This is the code number for the Survival and Environmental Systems volume of the RA-5C IPB.

Each volume of the IPB is divided into at least two sections and sometimes three--Section I, Introduction, Section II, Group Assembly Parts List, and Section III, when used, Numerical Index. The Introduction (Section I) contains detailed instructions for the use of the IPB. Section II includes illustrations of all parts of the applicable aircraft and its systems, equipment, and special support equipment subject to separate maintenance.

The latest type IPB has a separate volume for the Numerical Index. The Numerical Index contains an alphanumeric listing of all the parts in the IPB or volume. In addition to the part numbers, the Numerical Index contains such information as federal stock number data, figure and index numbers, source code data, and recoverability information.

The number of IPB manuals for some aircraft are numerous and for this reason some of the aircraft manufacturer's have published a Master Locator Index in conjunction with their IPB. This Master Locator Index is used to locate the IPB manual in which the part number is shown when only the part number is known. Most Master Locator Index pages are divided into 4 columns, each containing a part number and a manual number column. The number shown in the "Manual Number" column is the last dash number of the NavAir IPB manual in which the part will be found. Example: Part No. 128B10855, for an A-6A Aircraft, listed in the Master Locator Index, shows a "3" in the "Manual Number" column. This means that complete information on the part will be found in A-6A IPB, NavAir 01-85ADA-4-3. Once directed to a specific volume of the IPB the part can be further traced through the use of that volume's numerical index.

Prior to using any volume of the IPB, all of the information in Section I should be read. The information contained in this section will aid the AME in locating the necessary part or parts quickly and easily.

Technical Manual of Weight and Balance Data

This manual provides a standard system for field weight and balance control of certain aircraft. The forms, charts, and records in this manual are prepared by the manufacturer prior to delivery of the aircraft to the Navy and provide the means of maintaining a continuous and current record of the basic weight and balance and loading information during the aircraft's service life.

Procedures and instructions for maintaining the weight and balance records are contained in the manual. These records must be maintained by operating and overhaul activities and must be brought up to date prior to transfer of the aircraft. The manual must be retained in the aircraft at all times.

General Aircraft Manuals (01 Series)

To avoid confusion between the General Manuals (00 series) and general Aircraft Manuals (01 series), an explanation is in order at this point. This chapter is concerned with AERONAUTIC publications. There are many general aeronautic publications that do not directly concern aircraft; these are in the 00 series. There are other manuals that are applicable to aircraft in general without being identified with a specific model; these are general AIRCRAFT manuals. Some general aircraft manuals with which the AME works are as follows:

NA 01-1A-8, Aircraft Structural Hardware for Aircraft Repair.

NA 01-1A-509, Aircraft Cleaning and Corrosion Control for Organizational and Intermediate Maintenance Levels.

NA 01-1A-519, General Care, Use and Maintenance of Pressure, Vacuum, and Compound Gages.

ACCESSORIES MANUALS (03 SERIES)

The 03 series manuals cover all types of accessories. An accessory is defined as any item of equipment which is required for operation of the aircraft and which cannot be considered an integral part of the airframe or engine. Examples of accessories for which the AME is responsible are oxygen equipment, cabin pressurization and air-conditioning equipment, anti-icing equipment, and fire extinguishing equipment.

The manufacturer of each item of equipment (regulators, valves, cylinders, etc.) is required to provide adequate instructions for operating the item and maintaining it throughout its service life. Accessories Manuals therefore contain descriptive data; detail instructions for installation, operation, inspection, maintenance, and overhaul; and an illustrated parts list. All Accessories Manuals available for issue are listed in numerical order (by publication number) in the Accessories Section of Part C, Section VIII of NavSup Publication 2002. They are also listed in 00-500A, but in alphanumeric order according to part number. In 00-500B, Accessories Manuals are listed under the aircraft in which the accessory is installed.

Accessories Manuals are used to supplement information found in the aircraft Maintenance Instructions Manual. For example, when the Maintenance Instructions. Manual does not give instructions for repairing a particular item, reference should be made to the applicable Accessories Manual.

If any accessory is relatively simple, all the necessary instructions may be contained in a single manual. An example is NA 03-50B-6, Operation, Service and Overhaul Instructions with Illustrated Parts Breakdown for a Demand Oxygen Mask manufactured by the Ohio Chemical Co.

More complex accessories may require two or more manuals. For example, one manual may cover operation, service, and overhaul instructions, while the parts breakdown is contained in a separate manual.

To determine what manuals are available for a particular accessory, proceed as follows:

If the name of the manufacturer and the model number of the item are known, turn to the accessories section of NavAir 00-500A and locate the item in the alphabetical or numerical listing. All manuals applicable to that particular item of equipment will be listed by code number in appropriate columns opposite the name and model number of the item.

SUPPORT EQUIPMENT MANUALS (17, 18 and 19 SERIES)

The manufacturer of each item of support equipment is required to furnish adequate instructions for operating the equipment and maintaining it throughout its service life. Like aircraft Maintenance Instructions Manuals and Accessories Manuals, these publications prepared by the manufacturer are issued under the authority of the Naval Air Systems Command and are then official Navy publications.

The 17 and 18 series of aeronautic manuals provide information and instructions for most tools, machinery, and test equipment used in support of aircraft and components. Each item is covered by a manual which contains the purpose, procedures for preparing the item for use, operation, inspection, maintenance, lubrication, troubleshooting, and other pertinent data.

The 19 series manuals contain information on ground servicing and automotive equipment related to performing aircraft maintenance.

Support Equipment Manuals are stocked, cataloged, listed, and located in the same manner as Accessories Manuals.

NOTE: Ground support equipment data formerly provided as Descriptive Data Sheets (20 Series publications) are now identified as Ground Support Equipment Illustrations (GSEI). This information is coordinated with other branches of the service and is published and identified as MIL-HDBK-300.

SAFETY PRECAUTIONS MANUAL (NavMat P-5100 SERIES)

The safety precautions contained in this manual are applicable to all Navy personnel, military and civilian, and to all naval commands and activities. They are of necessity basic and general in nature and are not inclusive of all conceivable operations and functions involved in the great variety of Navy activities. In many instances references are made to other publications for detailed safety precautions applicable to specific conditions. A lack of documented hazards and pertinent precautions is not to be construed as an indication of their nonexistence or unimportance; therefore, the continuous cooperation and vigilance of all personnel is needed to see that all operating procedures and work methods do not unnecessarily expose personnel to injury or property to loss or damage.

Safety precautions shall be posted in a conspicuous place on or near any equipment, component, or material which presents a hazard to the security of the activity or to the safety of personnel. For example, those precautions necessary for the safe handling, stowage, and security of dangerous materials such as explosives or flammables shall be posted at or near the storage spaces designated for those materials.

Each individual is responsible for knowing, understanding, and observing all safety precautions applicable to his work and work area.

All chapters of the Safety Precautions Manual are extremely important, and the AME should be especially concerned with the chapter titled Aviation. This chapter covers general precautions applicable to the maintenance, repair, and overhaul of aircraft.

TECHNICAL INFORMATION FILE OF GROUND SUPPORT EQUIPMENT (MIL-HDBK-300B)

This publication is intended to provide, in concise and convenient form, factual pictorial and descriptive data to familiarize designers, engineering, maintenance and training personnel and Government contractors with the characteristics, performance capability and physical makeup of the ground support equipment presently in the inventory of the military services and under development for use with aircraft and missile systems. In the case of Government contractors, the data sheets are intended to provide sufficient information for determining that an item of equipment is suitable or unsuitable for a comtemplated application. This will insure the following:

1. Maximum usage of in-service assets.
2. Elimination of duplicate design or development of ground support equipment for different weapon systems.

This handbook contains information on ground support equipment for aircraft and missile weapon systems. Ground support equipment is construed to include ground operation, handling, and servicing equipment. Ground support equipment is further defined as all equipment required on the ground to make a weapon system operational in its intended environment.

Data sheets for the Technical Information File (TIF) will normally be selected or submitted only for ground support equipment items that have a unit cost of $1,000 and over or a potential or actual procurement total dollar value in excess of $100,000, regardless of unit cost.

Data sheets will not normally be acquired or submitted for common tools or power tools normally found in a standard machine shop; component parts or subassemblies of end items; kits, sets of tools, fixtures for manufacturing in depot use; sling, adapters, small containers, cabinets; or obsolete items of supply.

This handbook supersedes individual descriptive data sheets which were previously issued separtaely for each item of support equipment not covered by an individual technical manual.

ORDNANCE PUBLICATIONS

NavAir 11-100-1

Cartridges and Cartridge-Actuated Devices for Aircraft and Associated Equipment, NavAir 11-100-1, is an ordnance publication of vital interest to the AME. This publication is a looseleaf type manual and is commonly referred to as NavAir 11-100-1.

NavAir 11-100-1 has been designated by NavAirSysCom as the basis for the formulation of all maintenance instructions covering identification, handling, logbook entries, and service life for cartridges and cartridge-actuated devices utilized in naval aircraft. This means that the information in this manual takes precedence over that in all other related manuals and instructions.

A master copy of NavAir 11-100-1 is maintained in the technical library of all aircraft maintenance activities for utilization in the preparation of Maintenance Instructions concerning cartridges. Additional copies are generally found in the AME shops.

This manual gives information such as description and location, operation, identification and handling, and service life of cartridges and cartridge-actuated devices used in naval aircraft. Logbook entry information and safety precautions are included on each item. It gives illustrations of the cartridges and, where appropriate, identifies the systems using the cartridge. Schematics of some systems are also provided.

NavAir 11-85-1

Rocket Catapults and Rocket Motors for Aircrew Escape Systems, NavAir 11-85-1, is also an ordnance publication of vital interest to AME personnel.

This publication describes aircraft ejection seat rocket catapults and rocket motors used in various Navy aircraft, and sets forth handling procedures to be observed by fleet personnel ashore and aboard surface vessels. General and specific data are given for each catapult and rocket motor, including descriptions, nomenclature, handling instructions, and temperature and service life limitations. In the event of discrepancies between this publication and other publications containing information on the rocket catapults and rocket motors, this publication takes precedence.

LETTER TYPE PUBLICATIONS

TECHNICAL DIRECTIVES

The Technical Directive (TD) System has been established for control and issue of all technical directives. This system standardizes the method of issuance for such directives and is the authorized means for directing the accomplishment and recording of modifications and one-time inspections to equipment procured by and for the NavAirSysCom. The TD system is an important element in the programs designed to maintain equipment in a configuration which provides the optimum conditions of safety, operational, and material readiness. The system encompasses two types of technical directives differentiated by their method of dissemination. These two types are Formal (letter type) and Interim (message type). In general terms, they are both considered as letter type technical directives. Such directives contain instructions or information of a technical nature which cannot be satisfactorily disseminated by revisions or changes to technical manuals. This information is disseminated in the form of Changes, or in the case of special circumstances, by Interim Changes or Bulletins.

A formal TD is a document issued as a Change, or as an Amendment or Revision thereto, and promulgated by letter. Formal technical directives are used to direct the accomplishment and recording of modifications to weapons, systems, support equipment, trainers, and related equipment and are comprised of Changes and Amendments and/or Revisions thereto.

An interim TD is a document issued as a Bulletin or a Change, or as an Amendment or Revision thereto, and promulgated by message to insure expeditious dissemination. The interim TD is reserved for those instances requiring expeditious correction of an operational or safety condition which embodies risks calculated to be intolerable within the lead time of a formal directive or maintenance publication change. Interim Changes are superseded by a Formal Change directive which will have the same number as the interim directive. Interim Bulletin directives are not superseded by formal Bulletins as was previously the case. The NavSup Publication 2002, Section VIII, Part D, will still have many formal Bulletins listed until they are eventually phased out.

A Change is a document containing instructions and information which directs the accomplishment and recording of a material change, a repositioning, a modification, or an alteration in the characteristics of the equipment to which it applies. A Change is issued to direct that parts be added, removed, or changed from the existing configuration or that parts or material be altered, relocated, or repositioned.

A Change may be issued in parts to accomplish distinct parts of a total directed action or to accomplish action on different configurations of affected equipment. A Change may also be issued for record purposes. A Record Purpose Change is a TD issued to provide documentation of a modification which has been completely incorporated by the contractor or in-house activity in all accepted equipment and which does not require retrofit or the modification of repairables in the Navy's possession.

An Amendment is a document comprised of information which clarifies, corrects, adds to, deletes from, makes minor changes in requirements to, or cancels an existing technical directive. It is only a supplement to the existing directive and not a complete directive in itself. A maximum of three Amendments may be applied to any TD, each remaining in effect until rescinded or superseded by a Revision. A requirement for further amendment action necessitates the issuance of a Revision.

A Revision is a completely new edition of an existing technical directive. It supersedes the original directive or revision and all existing Amendments.

A Bulletin is an interim document comprised of instructions and information which directs an initial inspection to determine whether a given condition exists. It specifies what action is to be taken if a given condition is found or not found.

Interim Bulletin directives are self-rescinding with rescission dates of 30 June or 31 December, whichever is appropriate for the case at hand. Rescission is the process by which the TD's are removed from active files after all requirements have been incorporated. Final rescission action is direced in the TD Index, NavSup Publication 2002, Section VIII, Part D. All activities maintaining active technical libraries must maintain the TD's on file until they are deleted from the TD Index.

Cancellation of a technical directive is the process whereby the TD is removed from the active files when it is determined that a previously issued TD is not to be incorporated. Cancellation is directed by the issuance of an Amendment to the TD. The cancellation explicitly states the required configuration of each article initially specified for modification; for example, whether installed modifications are to remain installed or are to be removed, etc.

The title subject of a Change or Bulletin will be one of the following, as appropriate:

Airframe.
Powerplant.
Avionics.
Accessory.
Aviation Armament.
Aircrew System.
Propeller.
Photographic.
Support Equipment.
Airborne Weapon.
Clothing and Survival Equipment.
Target Control System.
Meteorological Equipment.

If the technical directive involves safety of flight, the word "SAFETY" will appear immediately following the title and number.

Technical directives are numbered by two different methods. Some are numbered consecutively from the beginning of the calendar year with the last two digits indicating the year of issue. Thus, a Change or Bulletin designated 47-54 would be the 47th change or bulletin of that type issued in 1954. This type of numbering system is no longer being used for identifying new directives. However, those which have been numbered in this manner and are still in effect are cataloged under this system.

The present numbering system is a consecutive numerical application regardless of the year of issue. For example, F-4 Airframe Change 204 would be the 204th Airframe Change that is applicable to the F-4 aircraft. This numbering system has been in effect for some time and most technical directives are cataloged under this system.

The numbers assigned to Changes and Bulletins are provided by the Technical Directives Control Center, which is located at the Naval Air Technical Services Facility (NATSF), Philadelphia. Changes or Bulletins that have been amended will have their basic number followed by the words "Amendment 1," "Amendment 2," etc. A revised directive will have the basic directive number followed with the words "Rev. A," "Rev. B," etc., as appropriate to denote the first, second, etc., revision to that basic directive.

The Changes and Bulletins are automatically distributed to all concerned activities through inclusion on the Mailing List Request for Aeronautic Publications, NavAir Form 5605/3. All TD's are issued by NavAir or NavAirTechSerFac except in cases where the time delay in obtaining approval is unacceptable. In such cases, the controlling custodians are authorized to issue interim TD's to preclude unacceptable risks to personnel or equipment. The Changes or Bulletins are generally based on Contractor Service Bulletins, other letters of recommendation, or proposed modifications from field service activities.

Directive Categories

Technical directives are assigned a "category" in accordance with the importance and urgency of accomplishing the work involved. A category of Immediate, Urgent, Routine, or Record Purposes is assigned each technical directive.

The category "Immediate Action" is assigned to directives which are issued to correct safety conditions, the uncorrected existence of which would probably result in fatal or serious injury to personnel, extensive damage, or destruction of property. Immediate Action directives involve the discontinued use of the aircraft, engines, or equipment in the operational employment under which the adverse safety condition exists, until the directive has been complied with. If the use of the aircraft, engines, or equipment will not involve the use of the affected component or system in either normal or emergency situations, compliance may be deferred, but should be accomplished no later than the next periodic inspection for the aircraft and no later than 120 days from the date of issue for the equipment. The Immediate Action directive is identified by a border of red X's broken at the top center of the page by the words "IMMEDIATE ACTION," also printed in red.

The category "Urgent Action" is assigned to directives which are used to correct safety conditions which, if uncorrected, could result in personnel injury or property damage. Such conditions compromise safety and embody risks calculated to be tolerable within narrow time limits and may or may not necessitate the imposition of operating restrictions. Urgent Action directives are identified by the words "URGENT ACTION" printed in red ink at the top of the first page and a border of red diagonals around the cover page.

The compliance requirement specifies that the incorporation of the instructions must be accomplished no later than the next regularly scheduled rework or overhaul or for equipment not reworked or overhauled on a regularly scheduled basis, not later than 18 months after the date of issuance.

Routine Action directives are issued where there are reliability, capability, or maintainability deficiencies which could, if uncorrected, become a hazard through prolonged usage or have an adverse effect on the operational life or general service utilization of equipment. The conditions embody a degree or risk or requirement determined to be tolerable within a broad time limit. The compliance requirement specifies the incorporation of the instructions not later than the next regularly scheduled overhaul or rework, or for equipment not reworked or overhauled on a scheduled basis, not later than 18 months after issuance of the directive. If accomplishment of the work requires Depot level maintenance capability, the compliance may be deferred if it will seriously interfere with operational commitments or schedules. Routine Action directives are identified by the words "ROUTINE ACTION" printed in black capital letters at the top center of the cover page.

The category "Record Purposes" is used on a technical directive when a modification has been completely incorporated by the contractor or in-house activity in all accepted equipment and when retrofit is not required on repairables in the Navy's possession. They are identified by the words "RECORD PURPOSES" printed in black capital letters at the top center of the cover page. This type of TD merely documents the action for configuration management purposes; therefore, compliance information is not applicable and is indicated as such.

INSTRUCTIONS AND NOTICES

Instructions and Notices are directives containing information and instructions concerning policy, administration, and air operations. They are issued by all bureaus, systems commands, ships, stations, and operating activities. Those issued by the Naval Air Systems Command are known as NavAir Instructions and Notices.

Instructions are directives of a continuing nature and are effective until canceled or superseded by a later directive.

Notices are directives of a one-time nature or directives which are applicable for a brief period of time. Each Notice contains a provision for its own cancellation.

Instructions are numbered in consecutive order according to the subject covered in the Instruction. Notices are numbered according to the subject covered and serialized by the date of issue. They may be addressed to "All Ships, Stations, and Units concerned with Naval Aircraft," or to certain activities only. Each activity maintains a file of all pertinent Instructions and Notices still in effect.

MISCELLANEOUS AVIATION PUBLICATIONS

Several other unofficial publications of general interest to aviation personnel are available in most operating activities. These should be read regularly by all maintenance personnel.

NAVAL AVIATION NEWS

The Naval Aviation News, NavAir 00-75R-3, is published monthly by the Chief of Naval Operations and the Naval Air Systems Command. Its purpose is to disseminate data on aircraft training and operations, space technology, missile, rocket, and other aviation ordnance developments, aeronautical safety, aircraft design, powerplants, aircraft recognition, technical maintenance, and overhaul procedures.

As its name implies, this publication is essentially a news magazine. It enables readers to keep abreast of the latest unclassified developments in every facet of naval aviation. In addition, the coverage of fleet operations and the human interest articles on the noteworthy feats and accomplishments of individuals, both officer and enlisted, make the Naval Aviation News an entertaining as well as an informational periodical.

APPROACH

Approach, NavAir 00-75-510, The Naval Aviation Safety Review, is published monthly by the U.S. Naval Aviation Safety Center and is distributed to all naval aeronautic organizations on the basis of 1 Copy for every 10 persons. It presents the most accurate information currently available on the subject of aviation accident prevention.

A large number of aviation accidents are maintenance-induced; that is, they occur during preparation for, performance of, and securing from maintenance or as a result of sloppy or improper maintenance. For instance, one fatality was reported which occurred when a maintenance man unintentionally ejected himself while arming an ejection seat. Additionally, a recent statistic reported in Approach revealed that in 9 accidents during a recent 15-month period 9 aircraft were lost—9 million dollars lost due to the omission of 9 cents worth of cotter pins.

The Approach magazine reports the results of accident investigations; and for those accidents that are maintenance-induced, describes what was done wrong and how it should have been done; suggests corrective measures to prevent future accidents resulting from these causes; and when appropriate, cites aeronautic technical publications which provide authority for changes in techniques or material to improve the maintenance product.

In short, the maintenance man who reads and heeds the messages in Approach is the man who benefits from other mechanics' experiences. Put Approach on your required reading list and look for it every month.

CROSSFEED

Crossfeeds are "Official Use Only" publications issued by the U.S. Naval Aviation Safety Center. Each Crossfeed is in the form of a letter to the squadron aviation safety officer.

Due to the designation "Official Use Only," the Crossfeeds are not available for general distribution throughout an activity. The restriction to "Official Use Only" derives from OpNav Instruction P3750.6 (Series) which states in part" . . . distribution of AAR's (Aircraft Accident Reports), incidents, and ground accident reports, MOR's (Medical Officer's Reports), reports of special investigations of aircraft mishaps, or extracts therefrom, will be limited strictly to commanders and other authorities named . . . ." Crossfeeds often contain such material extracted from AAR's and from reports of special investigations.

Crossfeeds are prepared according to subject matter. For instance, those about which the AME is most concerned are Personal/Survival Equipment Corssfeeds, Escape Crossfeeds, Maintenance Crossfeeds, and General Crossfeeds. From time to time these contain information of critical importance to the AME in the performance of his duties.

The unit's aviation safety officer will generally pass on Crossfeed information to those with an obvious need to know and will follow up to see that it is used. However, each applicable Crossfeed should be checked for pertinent information by the AME. It must be kept in mind that the average AME will only see an occasional Crossfeed unless he goes out of his way to look for them. For those who understand the need for special handling of the information contained in Crossfeed and are interested enough in the information and their jobs to ask for it, these publications can provide a wealth of useful and timely information.

MECH

MECH is published quarterly by the U.S. Naval Safety Center and is distributed to naval aeronautic organizations on the basis of 1 copy per 10 persons. It presents the most accurate information available on maintenance-caused mishap prevention and general aviation ground safety. Contents are informational and should not be considered as regulations, orders, or directives. Reference to commercial products does not imply Navy endorsement.

CHAPTER 3

HANDTOOLS, TUBING, AND FLEXIBLE HOSE

TOOLS

The AME3 and AME2 must have a thorough knowledge of the tools of his trade to enable him to increase his performance and the quality of his products. Using this knowledge and applying it in the right direction will aid in increasing the squadron's efficiency and operational availability. One of the most important factors that a mechanic can have is the ability to use the tools which are required to complete any given task in a skilled and technical manner.

A mechanic is known by the tools he keeps. The use of tools may vary; but safety, good care, and proper stowage of tools never vary. In this chapter, some of the various tools that the AME uses in the course of his duties are briefly described. The Rate Training Manuals, Tools and Their Uses, NavPers 10085 (Series), and Airman, NavPers 10307 (Series), also contain a description of most of the tools used by the AME, together with detailed instructions for using them. The material given in this chapter is intended to supplement, rather than repeat, the information given in Tools and Their Uses and the Airman manuals.

PROCUREMENT

Some activities have a centrally located toolroom which procures tools for the activity as a whole. This allows for better usage and accountability of the equipment. An activity's alloted amount of handtools is in accordance with an allowance which is established by NavAir 00-35QG-016, Consumable General Support Equipment for all Types, Classes, and Models of Aircraft, and the Individual Material Readiness List (IMRL).

NavAir 00-35QG-016 includes all of the accountable and consumable general support equipment which is required for the maintenance and operation of all types of aircraft at the Intermediate and Organizational levels of maintenance. Most of the tools listed in NavAir 00-35QG-016, appropriate for use by the AME, are found in the toolbox he is issued.

The Individual Material Readiness List (IMRL), which applies to an activity by name, specifies items and quantities of aircraft ground support equipment required for material readiness of the aircraft maintained by the activity.

Whenever the number of tools in the activity falls below a certain minimum, the central toolroom supervisor reorders to replenish his stock. The quantity status of tools on hand is determined by regular inventories.

CUSTODY

When it becomes necessary or desirable for an AME to have a toolbox assigned to him on a custody basis, the shop supervisor will notify the toolroom personnel to issue an AME toolbox to the designated person. Normally, the central toolroom will have a locally prepared toolbox inventory form. This form will be applicable to the particular aircraft, equipment, and maintenance level to be supported. They will issue the toolbox in accordance with this inventory form, making two copies—one (master copy) to be held by the central toolroom, and one to be placed in the toolbox. The AME should use this copy to inventory his toolbox after completion of each assigned task to insure that all of his tools have been placed back in his toolbox.

NOTE: Reinventory of tools taken to the jobs is a MUST to eliminate the possibility of damage to the aircraft due to foreign objects left adrift within or around the aircraft.

INVENTORY

The AME who has custody of a toolbox must prevent the loss of tools through neglect or misuse. Although handtools are normally classed as consumable items, they are very expensive and must be paid for when lost or carelessly damaged. One method of preventing loss of tools is a thorough inventory after each job assignment. Usually, the activity will have a local instruction concerning the inventory interval and method of reporting lost or damaged tools.

NOTE: Broken or damaged tools can damage aircraft hardware and parts. They can also cause personal injury to the worker or others.

At the periodic inventory, which is normally performed by central toolroom personnel, all broken or missing tools should be replaced. Non-productive time between job assignments provides ample time for further inspection and upkeep of toolboxes. Someone has said "show me a mechanic with a poor toolbox and I will show you a poor mechanic."

In addition to the tools normally issued with the toolbox, there are many special tools an AME3 or AME2 will come in contact with and use. Later in this chapter we will discuss just a few of these tools. Special tools are normally kept in the central toolroom and signed out on an as-needed basis. These tools are returned to the toolroom as soon as the AME has completed his work assignment. (Tools should be returned no later than the same day as checked out.)

Each activity has an allowance of special tools which they may have on custody. Often the allowance for an item is only one, which means positive control must be exercised. The special tools allowance list for a particular aircraft on which the AME might be working is contained in the activity's Individual Material Readiness List (IMRL) publications.

Some of the newer aircraft manuals list the special tools and equipment in one section of the Illustrated Parts Breakdown; for example, NavAir 01-75PAA-4-13, P-3A Special Support Equipment, and NavAir 01-245FDA-4-6, F-4A Special Support Equipment. When determining special support equipment allowances for any activity, refer to the Individual Material Readiness List.

HANDTOOLS

Before discussing the tools individually, a few comments on the care and handling of handtools in general might be appropriate. The condition in which an AME maintains his assigned tools determines his efficiency as well as affecting the judgment that his superiors pass upon him in his day-to-day work. A mechanic is always judged heavily by the manner in which he handles his tools.

Each mechanic should keep all his assigned tools in his toolbox when he is not actually using them. He should have a place for every tool, and every tool should be kept in its place. All tools should be cleaned after every use and before being placed in the toolbox. If they are not to be used again the same day, they should be oiled with a light preservative oil to prevent rusting. Tools that are being used at a workbench or at a machine should be kept in easy reach of the mechanic, but should be kept where they will not fall or be knocked to the deck. Tools should not be placed on finished parts of machines.

CAUTION: Handtools used in performing maintenance on oxygen systems should NOT be oiled. Tools should be completely free of any hydrocarbon materials such as grease and oil.

Handtools are classed according to the tasks they perform. These classifications are: cutting tools, turning tools, striking tools, holding tools, and miscellaneous handtools. These tools are explained as to their uses in the following paragraphs.

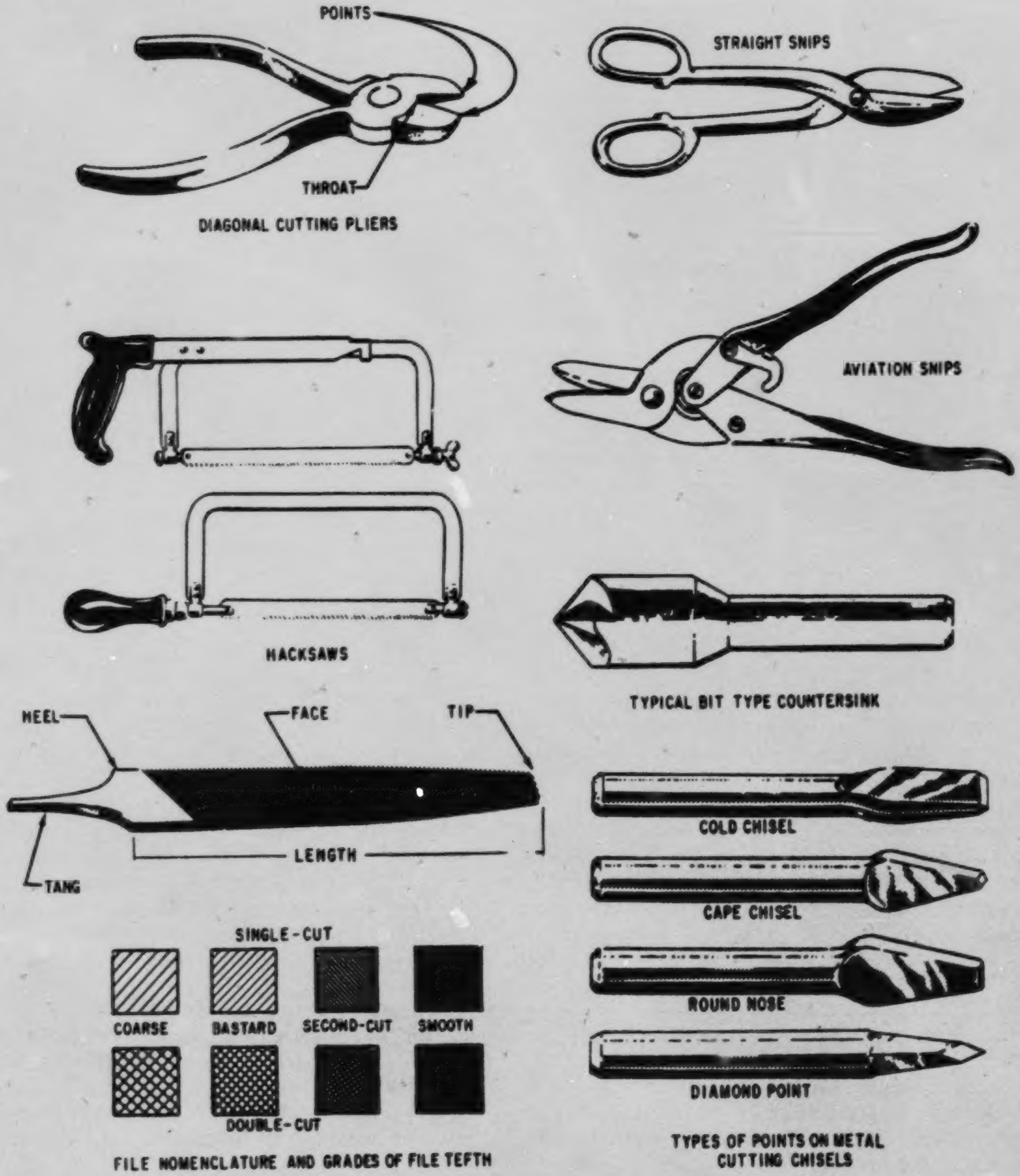
CUTTING TOOLS

Included in this group of tools are diagonal cutting pliers, files, hacksaws, twist drills, countersinks, chisels, and the various types of snips used by personnel to trim or cut material by hand. (See fig. 3-1.)

Adequate coverage on the selection, care, and use of cutting tools is contained in Tools and Their Uses, NavPers 10085 (Series), and Airman, NavPers 10307 (Series), and is therefore not repeated here.

TURNING TOOLS

Turning tools are the tools used for turning nuts, bolts, and screws. Those of primary interest to the AME are the socket wrench sets, which consists of several types of handles and bar extensions, universals, adapters, and a variety of sockets; combination wrenches, open end on one end and box end on the other; adjustable wrenches, commonly referred to as "knucklebusters"; common blade screwdrivers, for use on conventional slotted screws; crosspoint blade screwdrivers, for use on recessed


POINTS
STRAIGHT SNIPS
THROAT
DIAGONAL CUTTING PLIERS
AVIATION SNIPS
HACKSAWS
TYPICAL BIT TYPE COUNTERSINK
HEEL
FACE
TIP
LENGTH
TANG
COLD CHISEL
CAPE CHISEL
ROUND NOSE
DIAMOND POINT
TYPES OF POINTS ON METAL CUTTING CHISELS
SINGLE-CUT
COARSE
BASTARD
SECOND-CUT
SMOOTH
DOUBLE-CUT
FILE NOMENCLATURE AND GRADES OF FILE TEFTH

AM.1123

Figure 3-1.—Types of cutting tools.

head Phillips and Read and Prince type screws; and clutch tip blade screwdrivers, for use on screws with a clutch type recess. (See fig. 3-2.)

Adequate coverage on the selection, use, care, maintenance, and safety for turning tools is contained in Tools and Their Uses, NavPers 10085 (Series), and Airman, NavPers 10307 (Series), and is therefore not repeated here.

STRIKING TOOLS

Generally speaking, this group is composed of various types of hammers, all of which are used to apply a striking force where the force of the hand alone is insufficient. Each of these hammers is composed of a head and a handle, even though these parts differ greatly from hammer to hammer.

The mallet and the ball-peen hammer (fig. 3-3) are of the most concern to the AME and adequate coverage on their selection, use, care, and safety is contained in Tools and Their Uses, NavPers 10085 (Series), and Airman, NavPers 10307 (Series), and is therefore not repeated here.

HOLDING TOOLS

Holding tools refer to the various types of pliers employed to hold, secure, clamp, twist, bend, or act as wrenches in the performance of maintenance. Those of primary concern to the AME are vise grips, channel-lock, duckbill, needle-nose, and wire-twister pliers. (See fig. 3-4.)

Adequate coverage on their selection, use, care, and safety is contained in Tools and Their Uses, NavPers 10085 (Series), and Airman, NavPers 10307 (Series), and is therefore not repeated here.

MISCELLANEOUS TOOLS

Miscellaneous tools are tools that do not fall into the category of holding, turning, cutting, or striking tools. Some of the miscellaneous tools that are of concern to the AME are the flashlight, mechanical fingers, inspection mirrors, and steel scales. (See fig. 3-5.)

The Rate Training Manuals, Tools, and Their Uses, NavPers 10085 (Series), and Airman, NavPers 10307 (Series), adequately cover the use and care of these tools and is therefore not repeated here.

SPECIAL TOOLS

TORQUE WRENCHES

There are times when, for engineering reasons, a definite pressure must be applied to a nut. In such cases a torque wrench must be used. The torque wrench is a precision tool consisting of a torque-indicating handle and appropriate adapter or attachments. It is used to measure the amount of turning or twisting force applied to a nut, bolt, or screw.

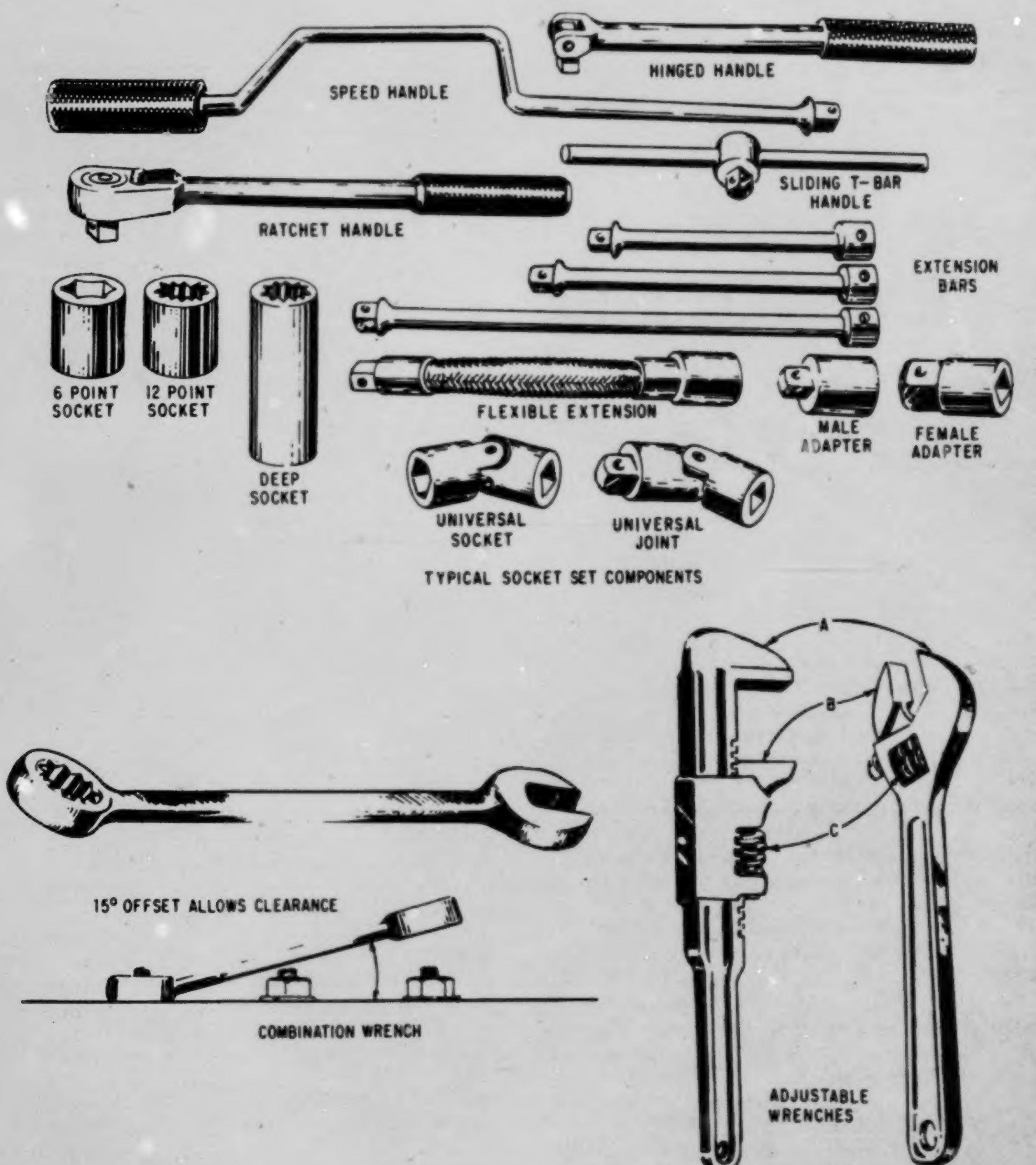
The three most commonly used torque wrenches are the Deflecting Beam, Dial Indicating, and Micrometer Setting types (fig. 3-6). When using the Deflecting Beam and the Dial Indicating torque wrenches, the torque is read visually on a dial or scale mounted on the handle of the wrench.

To use the Micrometer Setting type, unlock the grip and adjust the handle to the desired setting on the micrometer type scale, then relock the grip. Install the required socket or adapter to the square drive of the handle. Place the wrench assembly on the nut or bolt and pull in a clockwise direction with a smooth, steady motion. (A fast or jerky motion will result in an improperly torqued unit.) When the torque applied reaches the torque value which is indicated on the handle setting, the handle will automatically release or "break" and move freely for a short distance. The release and free travel is easily felt, so there is no doubt about when the torquing process is complete.

To assure getting the correct amount of torque on the fasteners, all torque handles must be tested at least once a month or more often if usage indicates it is necessary.

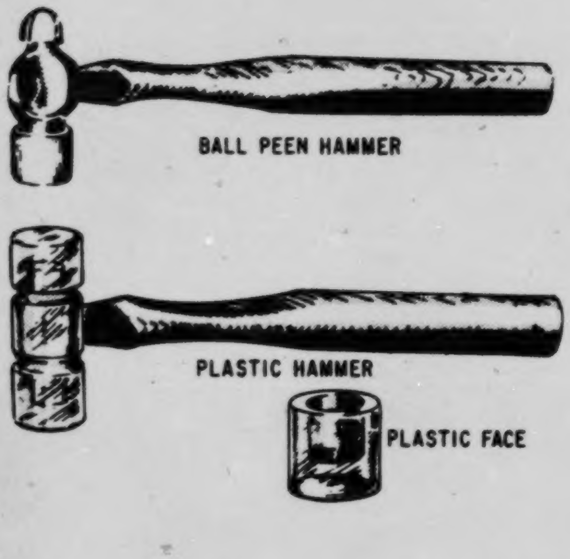
The following precautions should be observed when using torque wrenches:

1. Do not use the torque wrench as a hammer.
2. When using the Micrometer Setting type, do not move the setting handle below the lowest torque setting. However, it should be placed at its lowest setting prior to returning to storage.
3. Do not use the torque wrench to apply greater amounts of torque than its rated capacity.
4. Do not use the torque wrench to break loose bolts which have been previously tightened.
5. Never store a torque wrench in a toolbox or in an area where it may be damaged.


SPEED HANDLE
HINGED HANDLE
SLIDING T-BAR HANDLE
RATCHET HANDLE
EXTENSION BARS
6 POINT SOCKET
12 POINT SOCKET
DEEP SOCKET
FLEXIBLE EXTENSION
MALE ADAPTER
FEMALE ADAPTER
UNIVERSAL SOCKET
UNIVERSAL JOINT
TYPICAL SOCKET SET COMPONENTS
A
B
C
15° OFFSET ALLOWS CLEARANCE
COMBINATION WRENCH
ADJUSTABLE WRENCHES

AM.112

Figure 3-2.—Turning tools.



AM.23

Figure 3-3.—Striking tools.

SPANNER WRENCHES

Many special nuts are made with notches cut into their outer edge. For these nuts a hook spanner (fig. 3-7) is required. This is a wrench that has a curved arm with a lug on the end. This lug fits into one of the notches of the nut. The spanner may be made for just one particular size notched nut, or it may have a hinged arm to adjust it to a range of sizes.

Pin spanners have a pin in place of a hook, and the pin fits into a hole in the outer part of the nut. Face pin spanners are designed so that the pins fit into holes in the face of the nut.

AME's use several different types of spanner wrenches which are manufactured for a specific job. Figure 3-8 shows a special spanner being used on the firing mechanism of an ejection seat.

TENSIOMETER

The tensiometer is an instrument used in checking cable tension. The amount of tension applied in a cable linkage system is controlled by turnbuckles in the system. NOTE: Tension is the amount of pulling forces applied to the cable.

A tensiometer is a useful instrument, but is not precision-built. It is inaccurate for cable tensions under 30 pounds. All tensiometers in use must be checked for accuracy at least once a month.

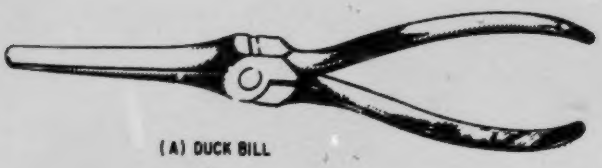
One type of tensiometer is shown in figure 3-9. This instrument works on the principle of measuring the amount of force required to deflect a cable a certain distance at right angles to its axis. The cable to be tested is placed under the two blocks on the instrument, and the lever assembly on the side of the instrument is pulled down. Movement of this lever pushes up on the center block, called a riser. The riser pushes the cable at right angles to the two clamping points. The force required to do this is indicated by a pointer on the dial. Different risers are used with different size cables. Each riser carries an identifying number and is easily inserted in the instrument.

Each tensiometer is supplied with a calibration table to convert the dial readings into pounds. One of these calibration tables is illustrated in figure 3-9. For example, in using a No. 2 riser with a 1/16-inch diameter cable, if the pointer on the dial indicates 48, the actual tension on the cable is 100 pounds. It will be noted that in the case of this particular instrument, the No. 1 riser is used with 1/16, 3/32-, and 1/8-inch diameter cables.

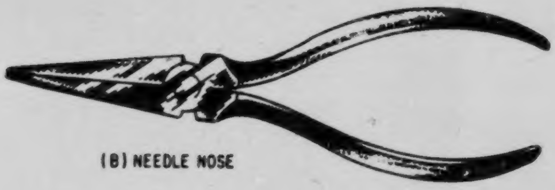
CAUTION: The calibration table applies to the particular instrument only and cannot be used with any other. For this reason, the calibration table is secured inside the cover of the box in which the instrument is kept. The chart is serialized with the same serial number as the instrument.

During the adjustment of turnbuckles, the calibration table must be used to obtain the desired tension in a cable. For example, if it is desired to obtain a tension of 110 pounds in a 3/16-inch diameter cable, the No. 2 riser is inserted in the instrument and the figure opposite 110 pounds is read from the calibration table. In this case the figure is 52. The turnbuckle is then adjusted until the pointer indicates 52 on the dial.

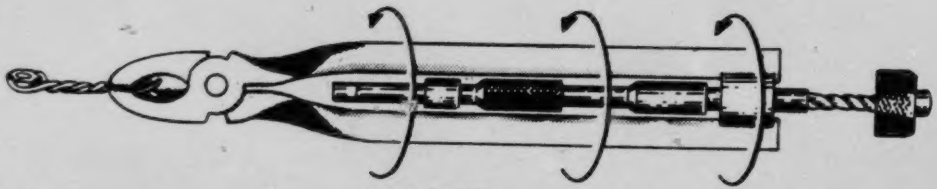
In some cases, the position of the tensiometer on the cable may be such that the face of the dial cannot be seen by the operator. In such cases, after the lever has been set and the pointer moved on the dial, the brake lever rod on the top of the instrument is moved forward and locks the pointer in place. Then the lever assembly is released and the instrument removed from the cable with the pointer locked in position. After the reading has been taken, the



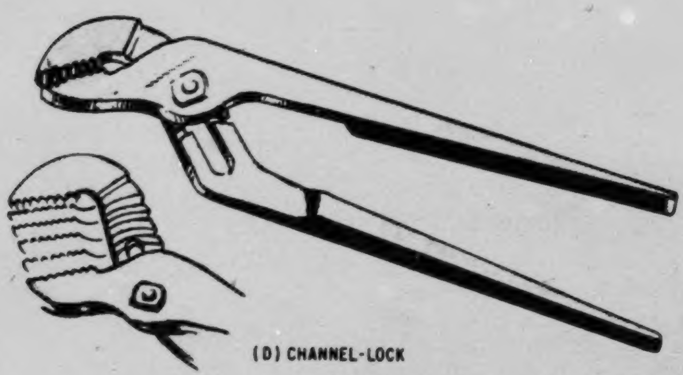
(A) DUCK BILL



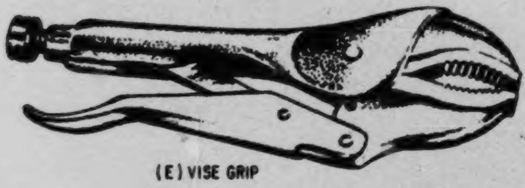
(B) NEEDLE NOSE



(C) WIRE TWISTER



(D) CHANNEL-LOCK



(E) VISE GRIP

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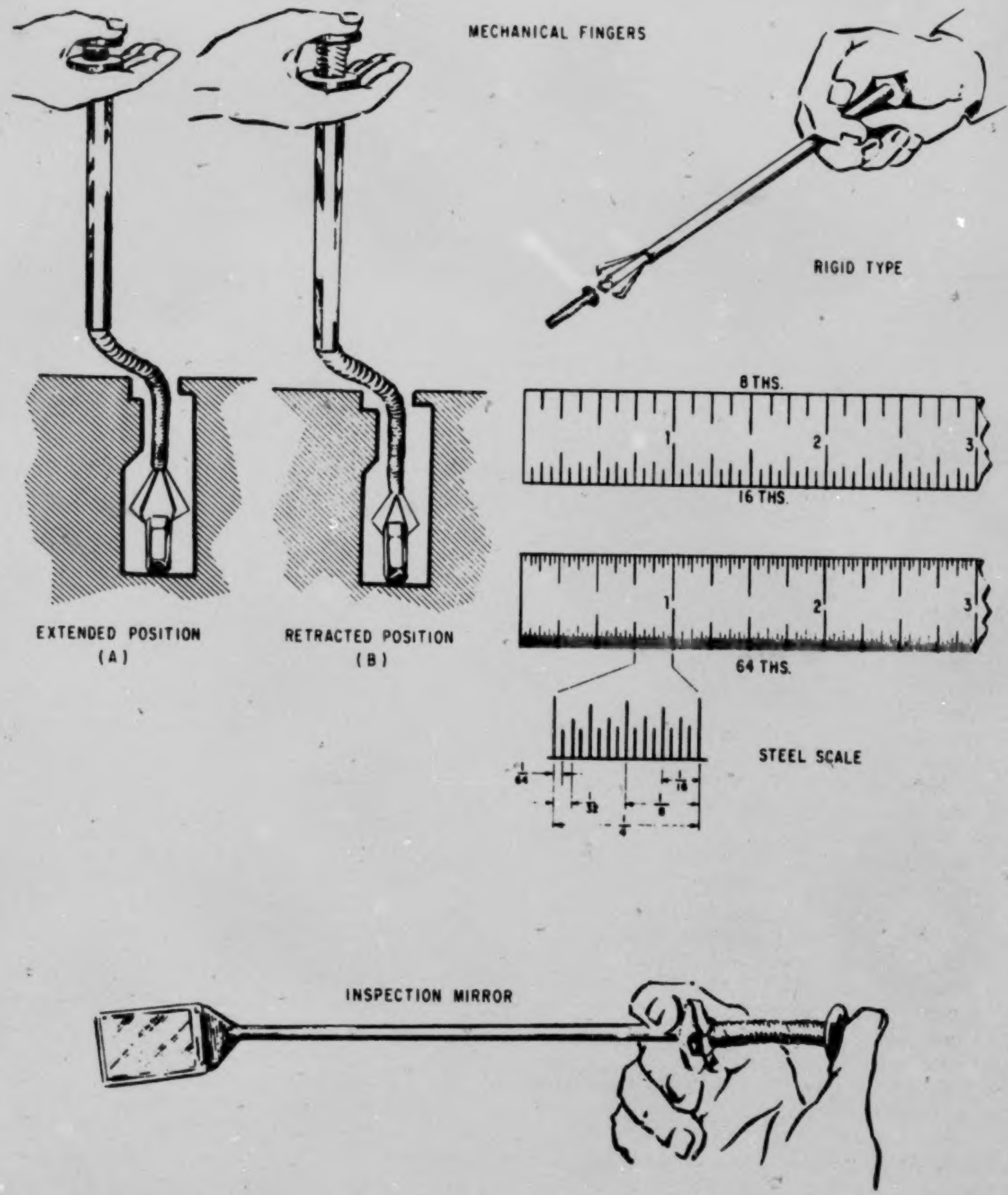
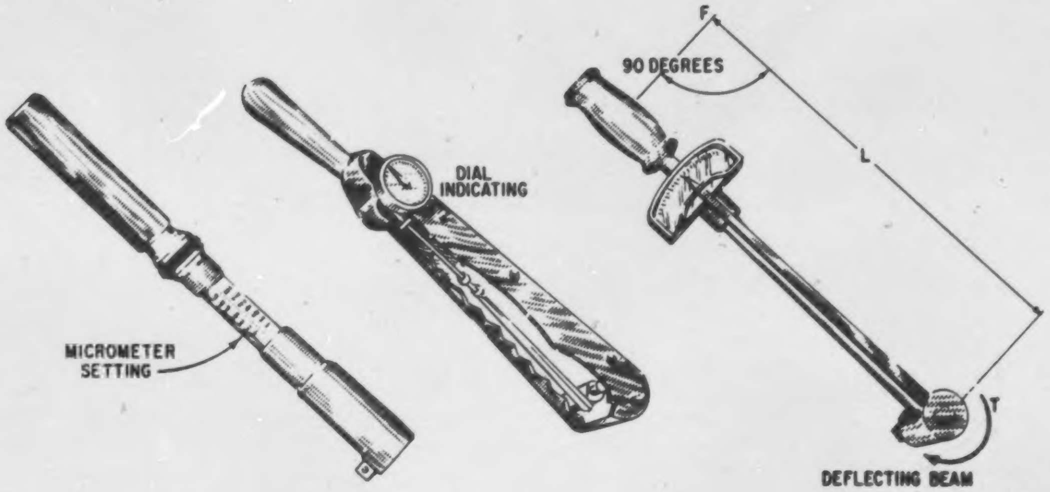
Figure 3-4.—Holding tools.


MECHANICAL FINGERS
RIGID TYPE
EXTENDED POSITION
(A)
RETRACTED POSITION
(B)
8 THS.
16 THS.
64 THS.
1
2
3
STEEL SCALE
1/64
1/32
1/16
1/8
1/4
INSPECTION MIRROR

AM.1126

Figure 3-5.—Miscellaneous tools.



AM.30

Figure 3-6.—Torque wrenches.

brake lever rod is moved to the off position and the pointer will return to zero.

The tensiometer, like any other measuring instrument, is a delicate piece of equipment and should be handled carefully. Tensiometers should never be stored in a toolbox.

Temperature changes must be considered in cable type systems since this will affect cable tensions. When a temperature is encountered that is lower than that at which the aircraft was rigged, the cables become slack because the aircraft structure contracts more than the cables. When temperatures higher than that at which the aircraft was rigged are encountered, the aircraft structure expands more than the cables, and the cable tension is increased.

The cable in any cable linkage system are rigged in accordance with a temperature chart which is contained in the applicable Maintenance Instructions Manual. This chart will give the proper tensions for the various temperature changes above and below the temperature at which the system was rigged.

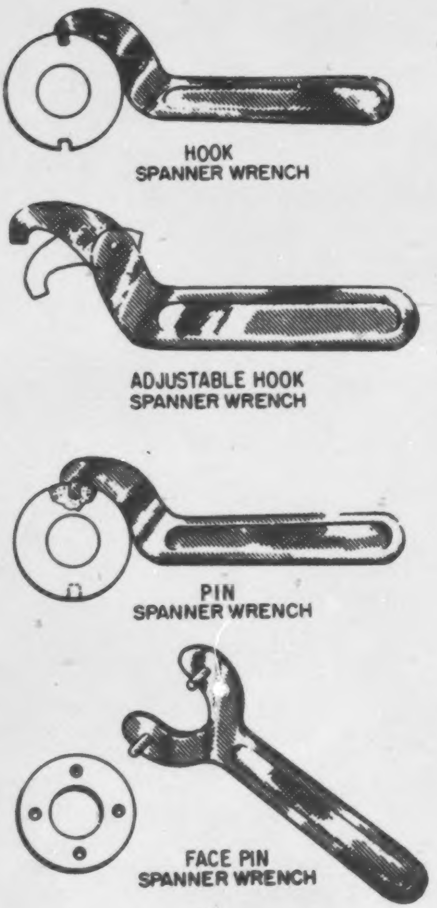
AIRCRAFT SPECIAL TOOLS

Each activity supporting aircraft has an allowance of special tools to support a specific model of aircraft. The allowance of special tools has already been explained in this chapter. The AME comes in contact with many of these tools while maintaining egress systems and pressurization and air-conditioning systems. Listed below are four of the special tools which the AME may use when maintaining the Martin-Baker Ejection Unit.

1. Top Latch Mechanism Handwheel. This tool (fig. 3-10) is used in the installation and removal of the Martin-Baker ejection seat. It is used to back the top latch plunger out of the ejection gun inner tube breech. (The top latch mechanism is described and illustrated in chapter 9.)
2. Spring Scale. Spring scales are used in many places when maintaining ejection seats. Figure 3-11 shows a spring scale being used to check sticker clip tension. (Sticker clips are discussed in chapter 9.)
3. Drogue Gun Cocking Tool. This tool (fig. 3-12) is used to cock the firing mechanism of the Martin-Baker drogue gun assembly.
4. Time Release Cocking Tool. This tool (fig. 3-13) is used for cocking both the rack plunger and the shackle release plunger.

TUBING

Modern day aircraft have hundreds of feet of fluid lines running throughout the wings and fuselage. These lines may be either rigid tubing or flexible hose.



AM.31

Figure 3-7.—General-purpose spanner wrenches.

Rigid tubing assemblies are made up mainly of aluminum alloy or stainless steel tubing. However, copper tubing is used in certain parts of some oxygen systems.

Two aluminum alloys are in common use—alloy 5052 may be used for lines carrying pressures up to 1,500 psi, and alloy 6061 for pressures up to 3,000 psi.

As a general rule, exposed lines are lines subject to abrasion, intense heat, or extremely high pressures, are made of stainless steel.

Flexible hose is generally used in connection with moving parts or where a line is subject to considerable vibration.

The AME is responsible for maintaining some of these fluid systems in the aircraft which frequently involves the fabrication and replacement of tubing and flexible hose assemblies.

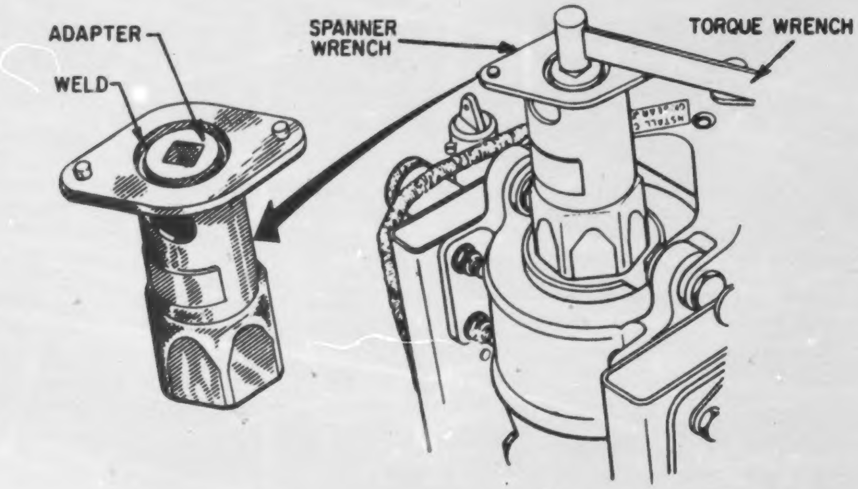
FLUID LINE IDENTIFICATION

Each fluid line in the aircraft is identified by bands of paint or strips of tape around the line near each fitting. These identifying media are applied at least once in each compartment. Various other information is also applied to the lines.

Identification tapes are applied to all lines less than 4 inches in diameter except cold lines, hot lines, lines in oily environment, and lines in engine compartments where there is a possibility of the tape being drawn into the engine intake. In these cases, and all others where tapes should not be used, painted identification is applied to the lines.

Identification tape codes indicate the function, contents, hazards, direction of flow, and pressure in the fluid line. These tapes are applied in accordance with MIL-STD-1247. This standard was issued in order to standardize fluid line identification throughout the Department of Defense. Figure 3-14 illustrates the method of applying these tapes as specified by this standard.

The function of a line is identified by use of a tape, approximately 1 inch wide, upon which word(s), color(s), and geometric symbols are printed. Functional identification markings, as provided in MIL-STD-1247, are the subject of international standardization agreement. Three-fourths of the total width on the left side of the tape has a code color or colors which indicate one function only per color or colors. The function of the line is printed in English across the colored portion of the tape; therefore, even a non English-speaking person can troubleshoot or maintain the aircraft if he knows the code but cannot read English. The right-hand one-fourth of the functional identification tape contains a geometric symbol which is different for every function. This is to insure that all technicians, whether English speaking or not, who may be colorblind may still be able to positively identify the line function by means of the geometric design rather than by the color(s) or word(s). Figure 3-15 is a listing, in tabular



AM.32

Figure 3-8.—Special spanner wrench.

form, of functions and their associated identification media as used on the tapes.

The identification-of-hazards tape shows the hazard associated with the contents of the line. Tapes used to show hazards are approximately one-half inch wide, with the abbreviations of the hazard contained in the line printed across the tape. There are four general classes of hazards found in connection with fluid lines. These hazards are outlined in the following paragraphs.

Flammable material (FLAM). The hazard marking "FLAM" is used to identify all materials known ordinarily as flammables or combustibles.

Toxic and poisonous materials (TOXIC). A line identified by the word "TOXIC" contains materials which are extremely hazardous to life or health.

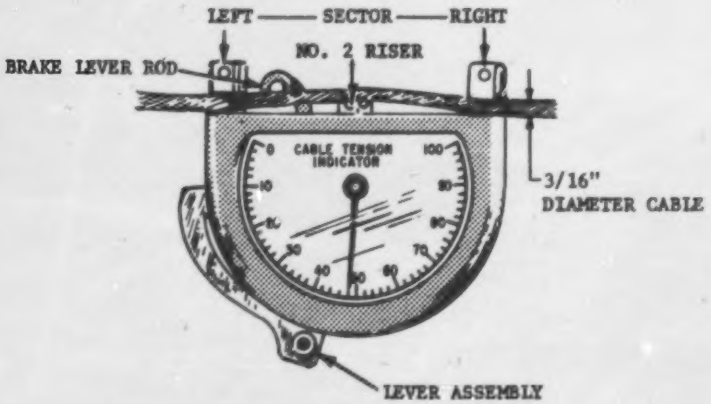
Anesthetics and harmful materials (AAHM). All materials productive of anesthetic vapors and all liquid chemicals and compounds hazardous to life and property, but not normally productive of dangerous quantities of fumes, or vapors, are in this category.

Physically dangerous materials (PHDAN). A line which carries material which is not dangerous with in itself, but which is asphyxiating in confined areas or which is generally handled in a dangerous physical state of pressure or temperature is identified by the marking "PHDAN."

Table 3-1 lists some of the fluids with which the AME may be required to work and the hazards associated with each.

Table 3-1.— Hazards associated with various fluids.

Contents	Hazard
Air (under pressure)	PHDAN
Alcohol	FLAM
Carbon dioxide	PHDAN
Freon	PHDAN
Gaseous oxygen	PHDAN
Liquid nitrogen	PHDAN
Liquid oxygen	PHDAN
LPG (liquid petroleum gas)	FLAM
Nitrogen gas	PHDAN
Oils and greases	FLAM
JP-5	FLAM
Trichlorethylene	AAHM


LEFT — SECTOR — RIGHT
NO. 2 RISER
BRAKE LEVER ROD
CABLE TENSION INDICATOR
0
10
20
30
40
50
60
70
80
90
100
3/16" DIAMETER CABLE
LEVER ASSEMBLY

No. 1				Riser	No. 2		No. 3	
DIA	1/16	3/32	1/8	Tension Lbs.	5/32	3/16	7/32	1/4
	14	15	21	30	14	20		
	18	22	27	40	18	25		
	23	27	33	50	22	29		
	27	32	39	60	26	33		
	31	37	44	70	29	37		
	35	41	49	80	32	41		
	39	45	54	90	35	45		
	43	49	59	100	38	48		
	46	53	63	110	41	52		
	49	57	67	120	44	55		
	53	61	71	130	47	58		
	56	65	75	140	49	61		
	59	68	79	150	51	64		
	62	71	82	160	54	67		
	65	74	86	170	56	70		
	68	77	90	180	58	72		
	70	80	93	190	60	74		
	72	83	96	200	62	76		
Typed figures are instrument scale reading corresponding to tension				220	66	81		
				240	70	85		
				260	74	89		
Instrument No. 6659 Model 401-1C-2				280	78	93		
				300	80	97		

AM.33

Figure 3-9.—Cable tensiometer and chart.

TUBING SIZES

The tubing used in the manufacture of rigid tubing assemblies is sized by outside diameter (OD) and wall thickness. Outside diameter sizes are in sixteenth-inch increments, the number of the tube indicating its size in sixteenths of an inch. Thus, No. 6 tubing is 6/16 or 3/8 inch;

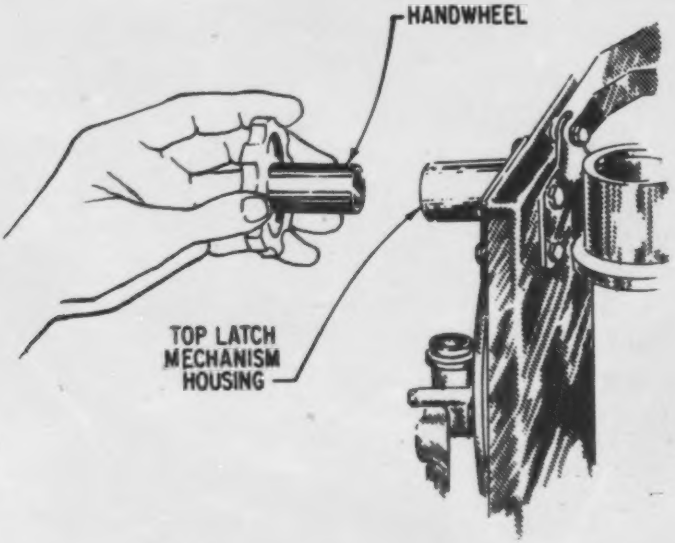


Figure 3-10.—Top latch mechanism handwheel.

No. 8 tubing is 8/16 or 1/2; etc. Wall thickness is specified in thousandths of an inch.

Replacement tubing assemblies should be fabricated from the same type material as the original part. Most aircraft Maintenance Instructions Manuals contain a table of acceptable substitutes which lists the original material and wall thickness and substitutes with wall thicknesses for each.

The Illustrated Parts Breakdown (IPB) for most aircraft provide necessary information to determine the correct tubing for the particular system. In many cases the IPB will refer to an applicable drawing number. The drawing will include specific information concerning the type of tubing, size, length of tubing runs between bends, etc. If the tubing section is complicated to manufacture and usage of the section (removal and replacement) justifies it, the tubing section may be stocked in the supply system as a standard stock item rather than a local manufacture item.

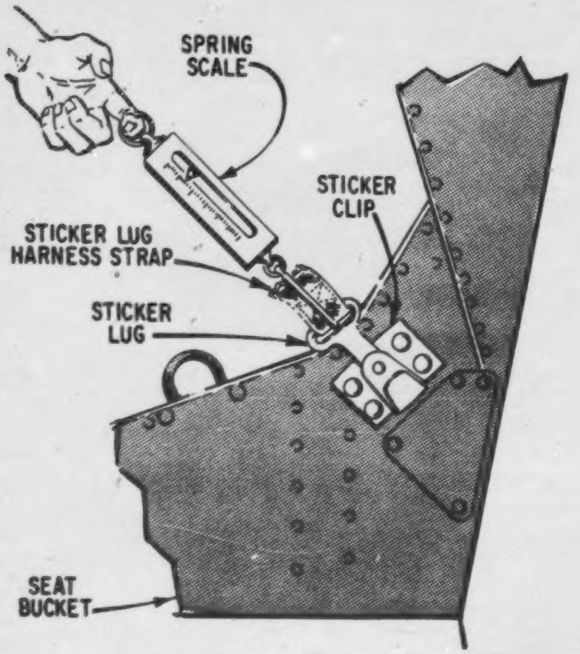
TUBE FITTINGS

Fittings for tube connections are made of aluminum alloy, steel, and corrosion-resistant steel (CRES). Fittings are made in many shapes and forms, each designed to fulfill certain requirements. The following paragraphs cover two common styles of tube fittings—the flared (AN) type and the flareless (MS) type. Also covered here is the metal lip-seal fitting, which is being used on the A-7 and A-4 aircraft.

Flared-Tube Fittings (AN)

The flared-tube fitting (fig. 3-16) consists of a sleeve and a nut. The sleeve fits directly over the tube, and one end is countersunk at the same angle as the tubing flare. The nut fits over the sleeve, and when tightened, draws the sleeve and tubing flare tightly against the male fitting (connector) to form the seal. The male fitting has a cone-shaped surface with the same angle as the inside of the flare. The sleeve supports the tube so that vibration does not concentrate at the edge of the flare, and distributes the stresses over a wider area for added strength.

Flared-tube fittings are identified by their color. Aluminum alloy fittings are blue, and steel fittings are black.



AM.35

Figure 3-11.—Use of a spring scale.

Flareless-Tube Fittings (MS)

The flareless-tube fitting shown in figure 3-17 consists of a sleeve and a nut. Notice that the tubing is not flared. (In order to effect a seal between the tubing and the sleeve, an operation called presetting is performed which is discussed later in this chapter). The connector has a counterbore, a portion of which is beveled 24 degrees. The seat in the connector forms a stop for the tube, and the beveled area causes the sleeve to seal the connection as the nut is tightened.

There are two types of flareless-tube fittings in current use. The newer most widely used type consists of a long sleeve (MS21922) and short nut (MS21921). The older type consists of a short sleeve (MS21918) and a long nut (MS 21917).

Flareless-tube fittings are made of aluminum and steel. The aluminum fittings are identified, visually, by their green and yellow color, which is caused from the anodizing treatment. Steel fittings are cadmium plated, which makes their color a silvery-white.

Metal Lip-Seal Fittings

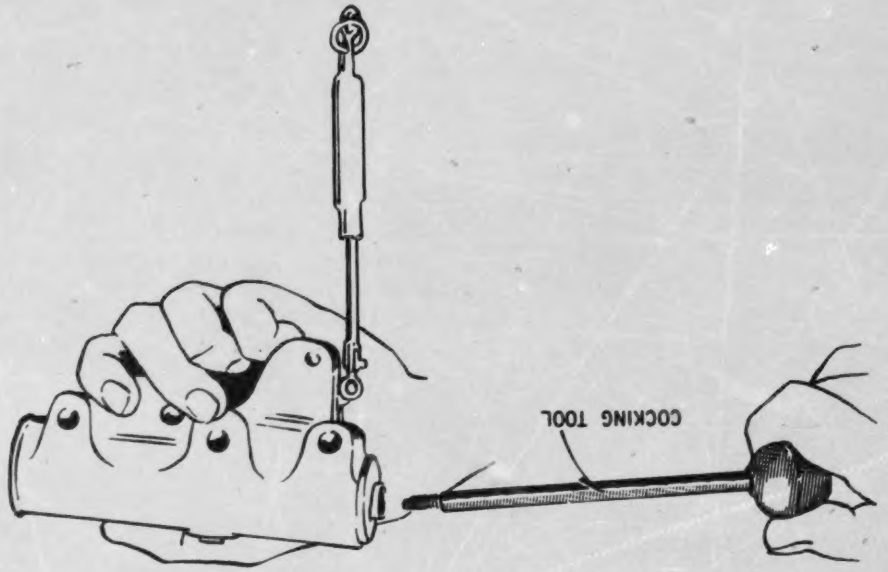
Metal lip-seal fittings (unions, reducers, and plugs) are utilized throughout most brazed tubing type systems. Figure 3-18 illustrates a metal lip-seal plug and union or reducer. These fittings are identical in application to the conventional fluid fitting common to most AM's. The major difference between conventional type fluid fittings and the lip-seal type is the manner in which they form a fluid pressure seal when installed in the port of a component. The conventional fitting requires the use of an O-ring seal. The metal lip-seal fittings utilize an integral metal contact seal (fig. 3-18). When the lip-seal fittings are installed in the port of a component and properly tightened, the metal contact seal area provides pressure-assist type sealing without the use of O-rings. The two types of fittings are completely interchangeable; however, the lip-seal fittings provide better system integrity because of the absence of O-rings.

Tapered Pipe
Thread Fittings

The threaded portion of pipe fittings used with oxygen system components are tapered so that when they are tightened, the male threads of the fitting are forced into the female (internal) threads of the component, creating a seal. Some Maintenance Instructions Manuals will call for using an approved military specification antisieze on the pipe threads to make removal of the fitting easier.

REMOVAL AND REPLACEMENT OF DAMAGED TUBING

All tubing is pressure tested prior to installation and is designed to withstand several times the operating pressure to which it will be subjected. If a tube bursts or cracks, it is generally the result of excessive vibration, improper installation, or from damage caused by collision with an object. All tubing failures should be carefully studied and the cause of the failure determined if possible. Replacements should be of the same size and material as the original or an acceptable substitute. The applicable Maintenance Instructions Manual usually



AM.36

Figure 3-12.—Drogue gun cocking tool.

lists acceptable substitutes for the original material.

LAYOUT OF LINES

A damaged line should be carefully removed so that it may be used as a template or pattern for the replacement item. If the old piece of tubing cannot be used as a pattern, an acceptable one can be made by placing one end of a piece of soft iron wire into one of the fittings where the tube is to be connected. Form the necessary bends in order to place the opposite end of the wire into the other connection. When the template satisfactorily spans the area between the fittings, it can be used as a pattern to bend the new tube.

Select a path with the least total degrees of bend, as this reduces flow loss and simplifies bending. Use a path with all bends in the same plane, if possible.

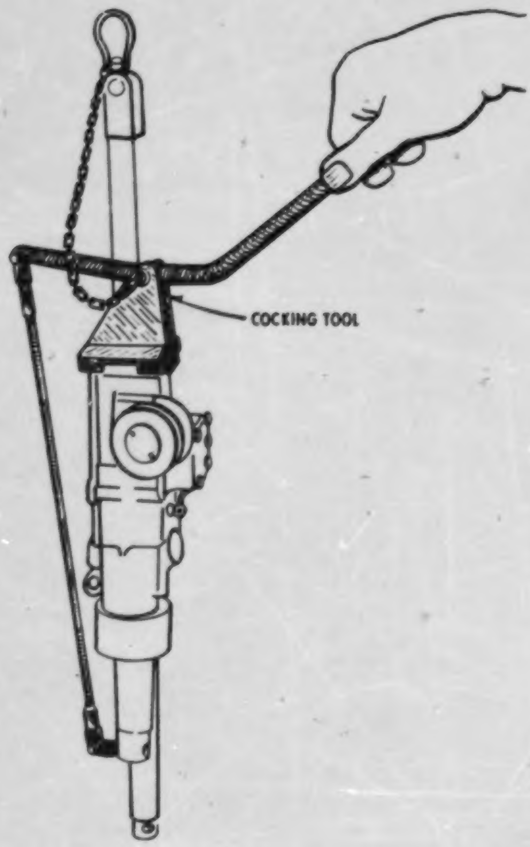
Never select a path that requires no bends. A tube cannot be cut or flared accurately enough so that it can be installed satisfactorily without bends. Bends are also necessary to permit the tubing to expand or contract under temperature changes and to absorb vibration. If the tube is small (under 1/4 inch) and can be hand formed, casual bends may be made to allow for this. If the tube must be machine formed, definite bends must be made to avoid a straight assembly.

Care must be taken to start all bends a reasonable distance from the end fittings, as the sleeves and nuts must be slipped back along the tube during the fabrication of flares and during inspections. In all cases, the new tube assembly should be so formed prior to installing that it is not necessary to PULL or DEFLECT the assembly into alignment by means of the coupling nuts.

TUBE CUTTING

The ideal objective, when cutting tubing, is to produce a square end, free from burrs. Tubing may be cut with a tube cutter or a fine-tooth hacksaw.

Correct use of the tube cutter is shown in figure 3-19. The procedure is as follows: Place the tube in the cutter with the cutting wheel at the point where the cut is to be made. Tighten



AM.37
Figure 3-13.—Time release cocking tool.

the adjusting knob so as to apply light cutter pressure on the tube, then rotate the cutter toward its open side, as shown in the illustration. As the cutter is rotated about the tube, continue to apply light pressure to the cutting wheel by intermittently tightening the knob. Too much pressure applied to the cutting wheel at one time may deform the tubing or cause excessive burrs. After the cut is completed, remove all burrs inside and outside, then clean the tube to make sure no foreign particles remain.

If a tube cutter is not available, a fine-tooth (32 teeth per inch) hacksaw may be used in cutting tubing. A convenient method of holding tubing when cutting it with a hacksaw is to place the tube in a flaring block and clamp the block in a vise. After cutting tubing with a hacksaw, all saw marks must be removed by filing. After filing, remove all burrs and sharp edges from the inside and outside of the tube as shown in figure 3-20. Clean out the tube and make sure no foreign particles remain.

TUBE BENDING

The objective in tube bending is to obtain a smooth bend without flattening the tube. Tube bending is usually accomplished with one of the tube benders discussed in this section; however, in case of an emergency, aluminum tubing under 1/4 inch in diameter may be bent by hand.

NOTE: Aluminum alloy tubing used in oxygen systems should not be bent by the hand method.

Hand Tube Bender

The hand tube bender (fig. 3-21) consists of four parts—handle, radius block, clip, and slide bar handle. The radius block is marked in degrees of bend ranging from 0 to 180. The slide bar handle has a mark which is lined up with the zero mark on the radius block. The tube is inserted in the tool; and after lining up the marks the slide bar handle is moved around until the mark on the slide bar handle reaches the desired degrees of bend on the radius block.

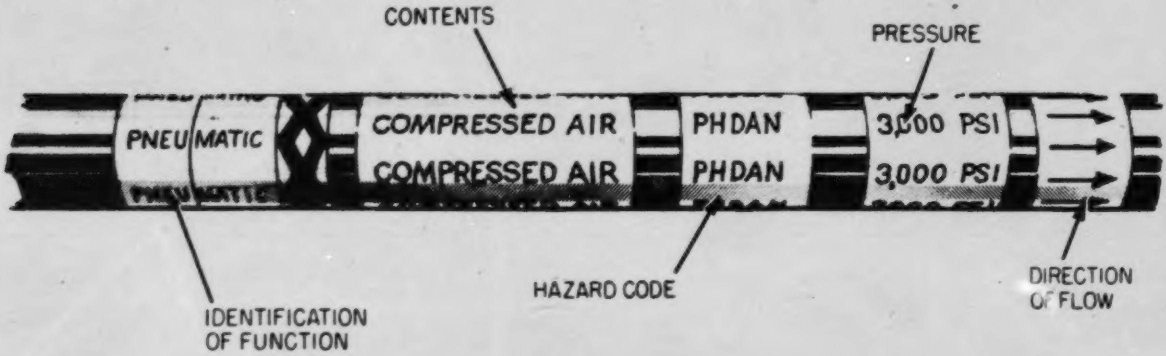
Mechanical Tube Bender

The tube bender shown in figure 3-22 is issued as a kit. The kit contains the equipment necessary for bending tubing from 1/4 inch to 3/4 inch in diameter.

This tube bender is designed for use with aircraft grade, high-strength, stainless-steel tubing, as well as all other metal tubing. It is designed to be fastened to a bench or tripod, and the base is formed so as to provide a secure grip in a vise.

The simple hand bender shown in figure 3-21 uses two handles as levers to provide the mechanical advantage necessary to bend the tubing, while this type tube bender employs a handcrank and gears. The forming die is keyed to the drive gear and secured by a screw (fig. 3-22).

The forming die on the mechanical tube bender is calibrated in degrees similar to the radius block of the hand type bender. A length of replacement tubing may be bent to a specified


CONTENTS
PRESSURE
PNEU MATIC
COMPRESSED AIR
COMPRESSED AIR
PHDAN
PHDAN
3,000 PSI
3,000 PSI
IDENTIFICATION OF FUNCTION
HAZARD CODE
DIRECTION OF FLOW

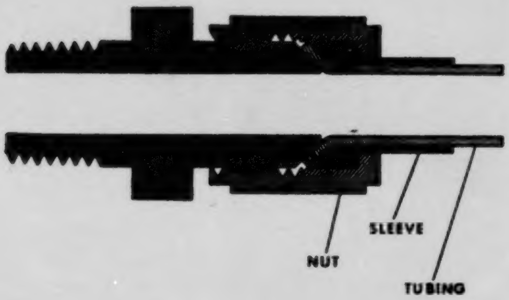
AM.66

Figure 3-14.—Fluid line identification application.

FUNCTION	COLOR	SYMBOL
Fuel	Red	✦
Rocket Oxidizer	Green, Gray	☽
Rocket Fuel	Red, Gray	✦☽
Water Injection	Red, Gray, Red	∨
Lubrication	Yellow	▪▪
Hydraulic	Blue, Yellow	●
Solvent	Blue, Brown	≣
Pneumatic	Orange, Blue	⧖
Instrument air	Orange, Gray	⟆
Coolant	Blue	~
Breathing Oxygen	Green	▬
Air Conditioning	Brown, Gray	⁘
Monopropellant	Yellow, Orange	┳
Fire Protection	Brown	◆
De-Icing	Gray	▲▲
Rocket Catalyst	Yellow, Green	⦀
Compressed gas	Orange	╱
Electrical Conduit	Brown, Orange	ϟ
Inerting	Orange, Green	✚✚

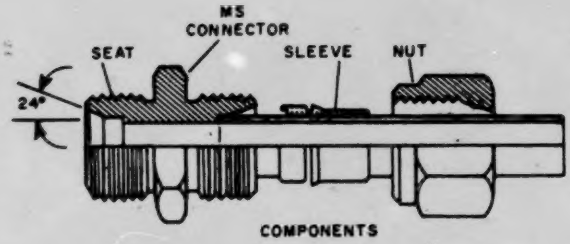
AM.67

Figure 3-15.—Functional identification tape data.


SLEEVE
NUT
TUBING

AM.68

Figure 3-16.—Flared-tube fitting.


MS CONNECTOR
SEAT
SLEEVE
NUT
24°
COMPONENTS

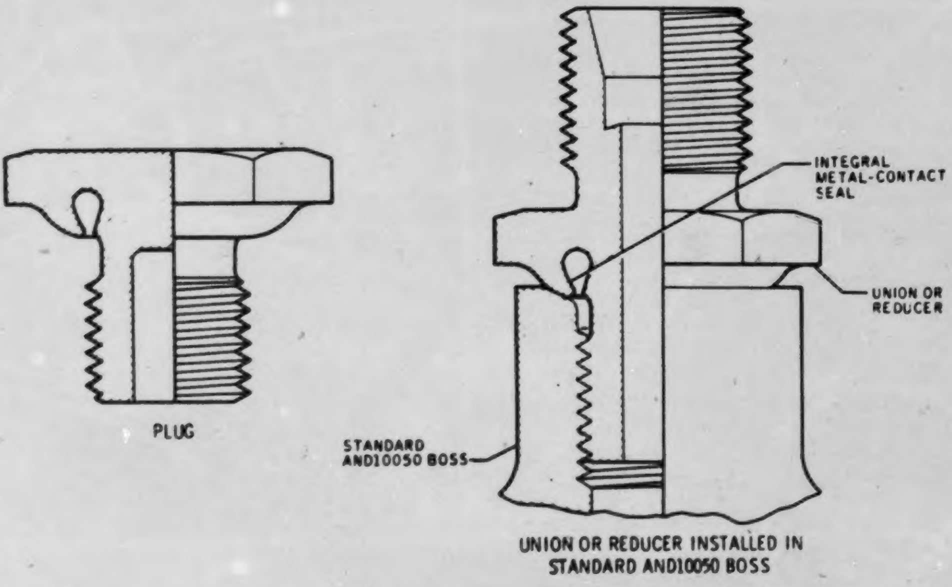
AM.69

Figure 3-17.—Flareless-tube fittings.

number of degrees or it may be bent to duplicate the bend in the damaged tube or pattern. Duplicating the bend of a damaged tube or pattern is accomplished by laying the pattern on top of the tube being bent and slowly bending the new tube to the required bend. NOTE: Certain types of tubing are more elastic than others; therefore, it may be necessary to bend the tube past the required bend to allow for springback.

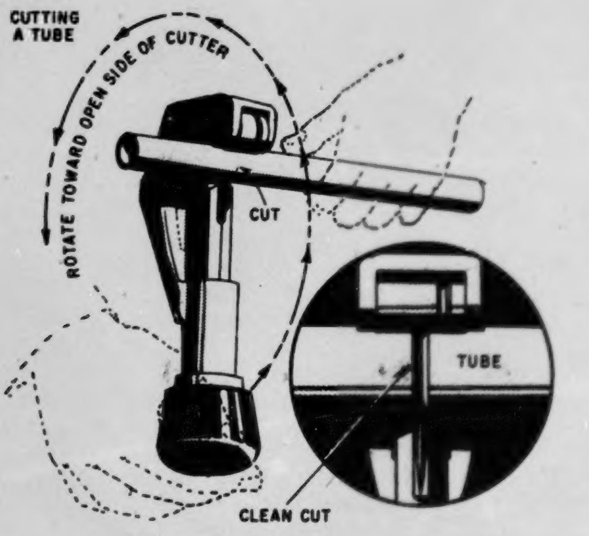
TUBE FLARING

A hand flaring tool similar to that shown in figure 3-23 is usually used for single flaring tubing. This tool consists of a flaring block or grip die, a yoke, and a plunger or flaring pin. The grip die consists of two steel blocks hinged at one end and held in alignment by a pilot pin. A number of countersunk holes, varying in size to conform with tube diameters and with countersinks matching standard flare angles and radii,


PLUG
STANDARD AND10050 BOSS
INTEGRAL METAL-CONTACT SEAL
UNION OR REDUCER
UNION OR REDUCER INSTALLED IN STANDARD AND10050 BOSS

AM.933

Figure 3-18.—Metal lip-seal fittings.



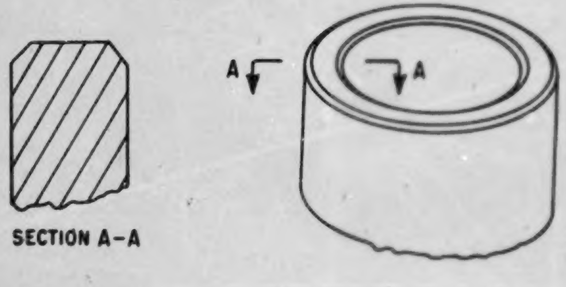
AM.70

Figure 3-19.—Tube cutting.

are provided with half of the hole in each block.

The yoke fits over the two halves of the grip die and has a setscrew which is used to lock the yoke at the desired position. The yoke also serves as a centering guide for the plunger. The plunger is tapered to the same angle as the countersunk holes in the grip die.

To flare the end of a tube with this tool, slip the fitting nut and sleeve onto the tube and place the tube in the proper size hole in the grip die. (The end of the tube should extend 1/64 inch above the surface of the grip die.) Center the plunger over the end of the tube and tighten the yoke setscrew to secure the tubing in the grip die and hold the yoke in place. The flare is made by striking the plunger several light blows with a hammer or mallet. Turn the plunger a half turn after each blow and make sure it seats properly before removing the tube from the grip die. After completing the flare, inspect to insure that no cracks are evident. NOTE: The flared end of the tube should not be any larger than the largest diameter of the sleeve being used.



AM.71

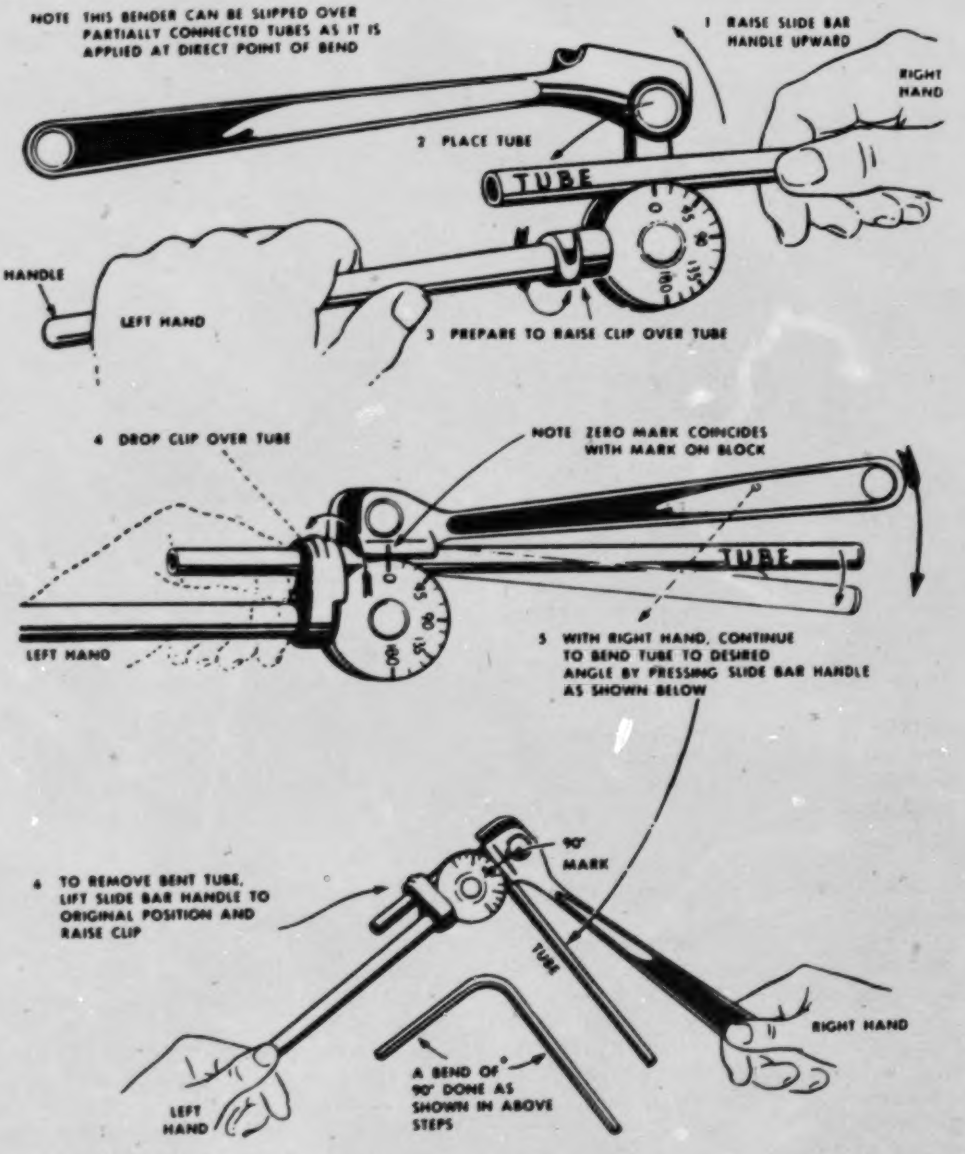
Figure 3-20.—Properly burred tubing.

Double flares should be used on all 5052 aluminum alloy tubing up to 3/8-inch diameter. Steel tubing need not be double flared. The double flare reduces cutting of the flare by overtightening and the consequent failure of the tubing assembly under operating pressure. Aluminum alloy tubing used in low-pressure oxygen systems should always be double flared. Figure 3-24 (views A and B) shows two of the tools used in the manufacture of double flared tube assemblies. Figure 3-24 (view C) shows the results of proper and improper flaring.

This flaring tool is issued as a kit. The kit contains a tool body, a ram, and a finish flare punch. Also included are a set of die blocks and an upset flare punch for each size of tubing which may be flared with this kit.

To double flare a tube assembly, prepare the end of the tube as shown in figure 3-20. Select the proper size die blocks and proceed as follows:

1. Place one-half of the die block in the flaring tool body with the countersunk end towards the ram guide.
2. Install the nut and sleeve and lay the tubing in the die block with approximately 1/2 inch protruding beyond the countersunk end.
3. Place the other half of the die block into the tool. Close the latch plate and tighten the clamp nuts finger tight.
4. Insert the upset flare punch in the tool body with the gage end toward the die blocks. NOTE: One end of the upset flare punch is counterbored or recessed to gage the amount of tubing needed to form a double lap flare. Insert the ram and tap lightly with a hammer or mallet until the upset flare punch meets the die blocks and the die blocks are firmly set against the stop plate on the bottom of the tool.


NOTE THIS BENDER CAN BE SLIPPED OVER PARTIALLY CONNECTED TUBES AS IT IS APPLIED AT DIRECT POINT OF BEND
1 RAISE SLIDE BAR HANDLE UPWARD
RIGHT HAND
2 PLACE TUBE
TUBE
0
45
90
135
180
HANDLE
LEFT HAND
3 PREPARE TO RAISE CLIP OVER TUBE
4 DROP CLIP OVER TUBE
NOTE ZERO MARK COINCIDES WITH MARK ON BLOCK
TUBE
LEFT HAND
5 WITH RIGHT HAND, CONTINUE TO BEND TUBE TO DESIRED ANGLE BY PRESSING SLIDE BAR HANDLE AS SHOWN BELOW
90° MARK
6 TO REMOVE BENT TUBE, LIFT SLIDE BAR HANDLE TO ORIGINAL POSITION AND RAISE CLIP
TUBE
RIGHT HAND
A BEND OF 90° DONE AS SHOWN IN ABOVE STEPS
LEFT HAND

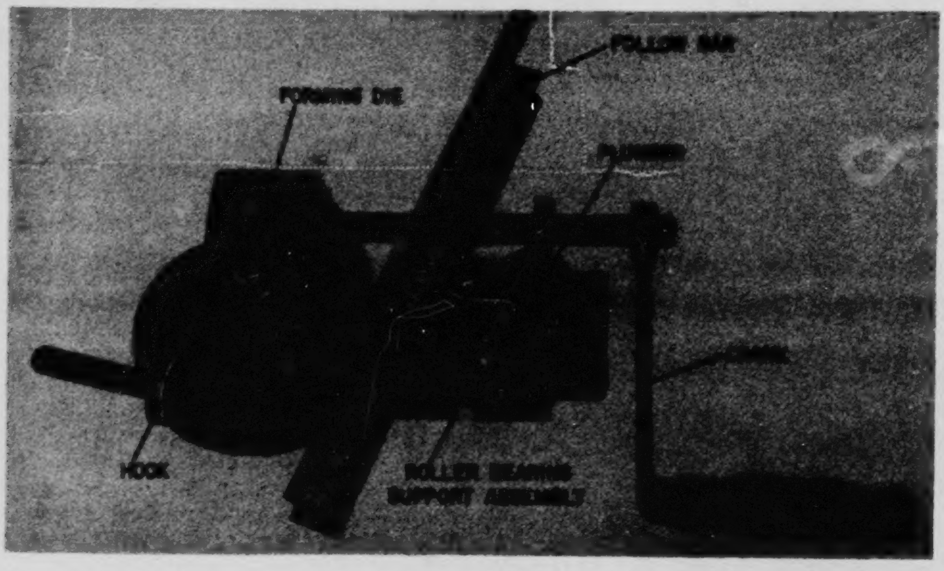
AM.72

Figure 3-21.—Tube bending.

5. Tighten the latch plate nuts with a wrench. Tighten the nuts alternately, beginning with the closed side to prevent distortion of the tool.

6. Reverse the upset flare punch and insert it in the tool body. Insert the ram into the tool body and tap lightly with a hammer or mallet until the upset flare punch contacts the die blocks.

7. Remove the upset flare punch and ram. Insert the finishing flare punch and ram. Tap



AM. 73

Figure 3-22.—Mechanical tube bending tool.

the ram lightly until a good seat is formed. Always check the seat at intervals during the finishing operation to avoid overseating.

A finished double flare is shown in figure 3-24 (view C).

CAUTION: When fabricating oxygen lines, insure that all tools are kept free of oil and grease.

Double flaring 5/16-inch oxygen tubing requires a slightly different flaring procedure using a hand flaring tool similar to the one shown in figure 3-24, view B.

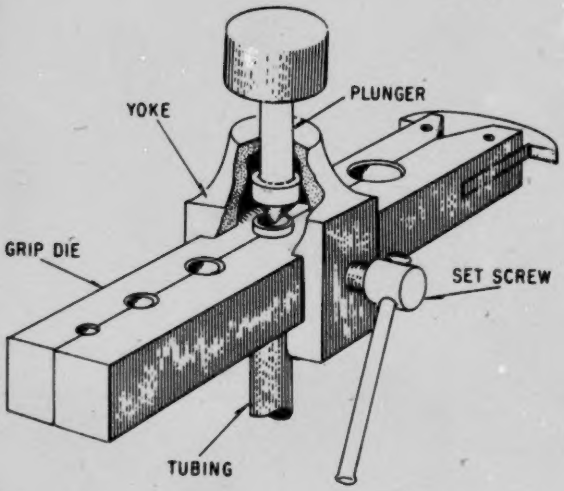
The tubing is prepared for flaring in the same manner as previously discussed, and the sleeve and nut are placed on the end of the tubing. The clamp blocks of the flaring tool are separated, and the tubing is placed between the clamp blocks with the tubing protruding slightly above the top surface of the blocks. Next, close the clamp blocks, slide the harness into position and tighten the clamp blocks by tightening the screw and bar type handle on the side of the harness, using moderate tightening force.

Hold the flare tool in the palm of the hand, as shown in figure 3-24, view B, with the tubing extended between the second and third fingers. Insert the gaging pin into the pin guide hole and tap the gaging pin with a light hammer until the shoulders of the pin stop against the clamp blocks. Remove the gaging pin from the pin guide hole.

Tighten the clamp blocks securely to prevent any sliding of the tubing during the flaring steps. Hold the tool as before and insert the starting pin into the pin guide hole and hammer it with sharp blows of moderate force until the shoulder of the starting pin stops against the clamp blocks.

Remove the starting pin and insert the finishing pin in its place. Hammer the finishing pin in the same manner until the shoulder of the finishing pin stops against the clamp blocks. Remove the finishing pin and unclamp the tubing.

If the flaring tool is used correctly, the outside diameter of the flare should be within the specified tolerance. Incorrect flares should be cut off and the tubing flared again. A short inner flare is caused by inserting the tubing too low in the clamp blocks or by the tubing slipping in the clamp blocks during the flaring operation. It should not be used because of the short bearing surface against the fitting nipple.



AM.74
Figure 3-23.—Tube flaring tool (single flare).

A long inner flare is caused by improper gaging and should not be used as it will restrict the flow passage.

PRESETTING FLARELESS TUBE FITTINGS

Although the use of flareless-tube fittings eliminates all tube flaring, another operation, referred to as PRESETTING, is necessary prior to installation of a new flareless-tube assembly. Presetting is necessary to form the seal between the sleeve and the tube without damaging the connector.

Presetting should always be accomplished with a presetting tool as shown in figure 3-25. These tools are machined from tool steel and hardened so that they may be used with a minimum of distortion and wear. It is recommended that a mandrel be used during the sleeve presetting operation. A mandrel consists of a short piece of solid bar of any hard material such as steel. It should have an outside diameter of 0.002 to 0.005 inch less than the inside diameter of the tube. Using a mandrel assists in attaining an improved sleeve cut during the presetting operation. For field use, a short piece of drill rod of the proper diameter may be used as a mandrel. The mandrel should be long enough to support the tube inside diameter at the sleeve cut and also at the point where the sleeve shoulder grips the tube.

NOTE: A connector may be used as a presetting tool in an emergency. However, when connectors are used as presetting tools, aluminum connectors should be used only once and steel connectors should not be used more than five times. The presetting operation is described in the following paragraphs:

NOTE: There are two types of flareless-tube fittings in current use. The older type consists of a short sleeve (MS21918) and a long nut (MS 21917). The newer type consists of a long sleeve (MS21922) and a short nut (MS21921). The presetting operation for the two types differs to some extent. These differences are pointed out as applicable in the following discussion:

1. Cut the tubing to the correct length, with the ends perfectly square. Burr the inside and outside of the tube. Slip the nut and then the sleeve over the tube, making certain that the pilot and the cutting edge of the sleeve point toward the end of the tube. (See fig. 3-25.) If a mandrel is used, it should be inserted in the tube at this time.

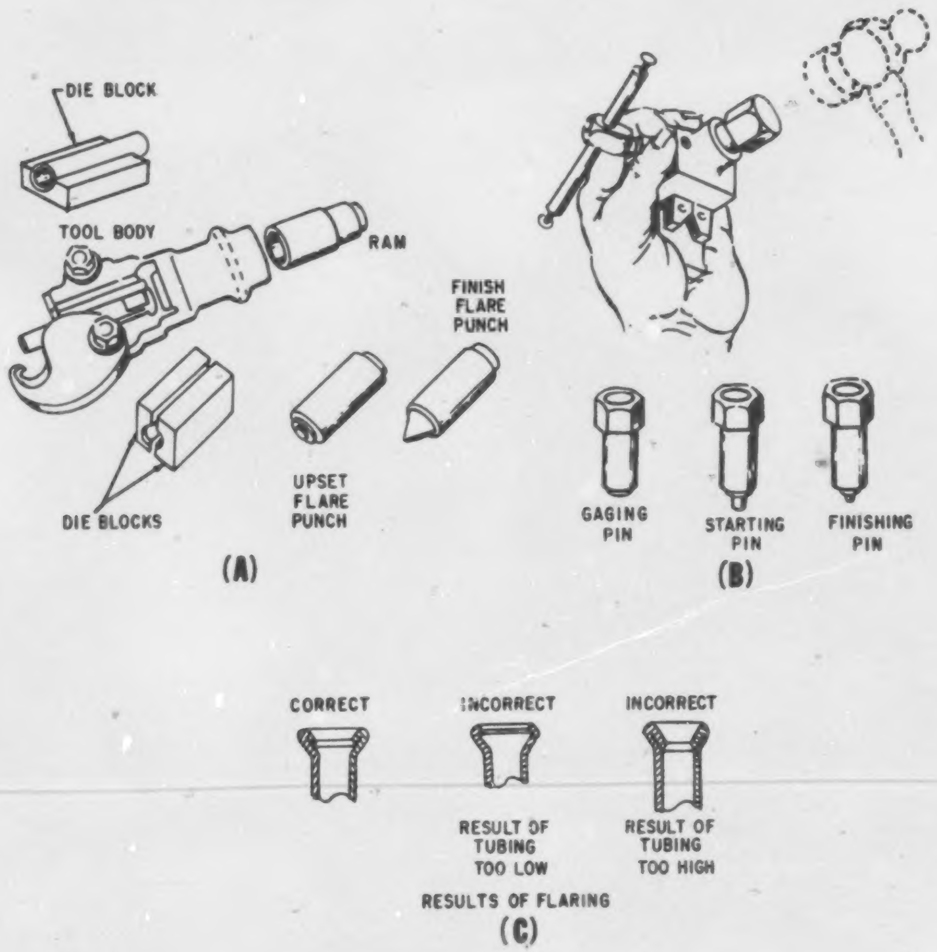
2. Lubricate the threads of the presetting tool and the nut with the approved lubricant. Hydraulic fluid, Specification MIL-H-5606, is the approved lubricant for hydraulic lines; and pneumatic grease, Specification MIL-G-4343, is the approved lubricant for pneumatic lines. Refer to NA 01-1A-8, Structural Hardware, for the approved lubricants for other systems.

CAUTION: Hydraulic fluid or any other petroleum base lubricants must not be used as a thread lubricant for oxygen lines.

3. Place the tool in a vise and hold the tubing firm and square on the seat in the tool. (The end of the tube must bottom firmly in the tool.) The tube should be rotated slowly between the thumb and fingers while the nut is turned down until the sleeve seizes on the tube. When the tube no longer turns, the nut is ready for final tightening.

4. The final tightening force necessary to set the sleeve on the tube depends on the type of fitting. When presetting the older type fittings, tighten the nut (MS21917) 1 1/6 more turns for all sizes of tubing and all types of tubing material. This force sets the sleeve (MS21918) on the tube.

When presetting the newer type fitting—the long sleeve (MS21922) and the short nut (MS 21921)—the required tightening force varies. If a mandrel is used, the final tightening force


DIE BLOCK
TOOL BODY
RAM
FINISH FLARE PUNCH
UPSET FLARE PUNCH
DIE BLOCKS
(A)
GAGING PIN
STARTING PIN
FINISHING PIN
(B)
CORRECT
INCORRECT
INCORRECT
RESULT OF TUBING TOO LOW
RESULT OF TUBING TOO HIGH
RESULTS OF FLARING
(C)

AM.1127

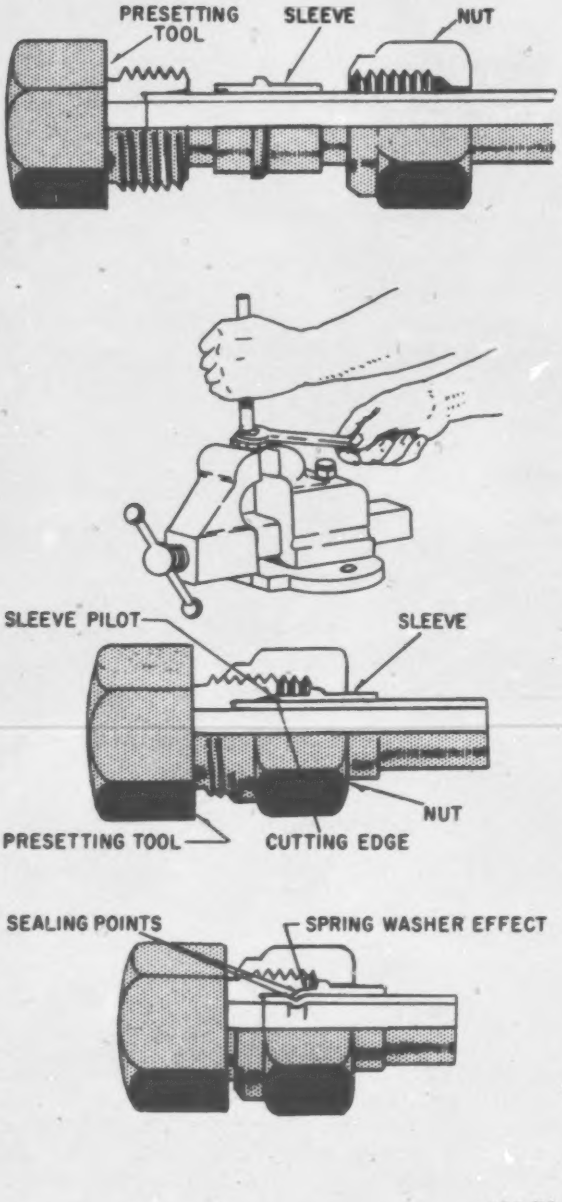
Figure 3-24.—Tube flaring tools (double flare).

varies with the size of the tubing. If a mandrel is not used, the tightening force varies with the size, wall thickness, and material of the tubing. Tables of these tightening forces (turn values) are presented in NA 01-1A-8. These tables should be consulted when presetting this type fitting.

The final tightening force permanently assembles the sleeve to the tube. Sleeves should not be removed from the tube and reused under any conditions.

After presetting (fig. 3-26), the nut should be uncoupled from the presetting tool, and the sleeve and tube inspected for the following:

1. The sleeve cutting lip should be embedded into the tube outside diameter approximately 0.003 to 0.008 inch (distance (X) in figure 3-26), depending on the size and material of the tubing. As shown, a lip of material will be raised under the pilot. The pilot of the sleeve should contact or be quite close to the outside diameter of the tube. (See distance (Y).) The tube projection from the pilot of the sleeve to the end of the tube



AM.76

Figure 3-25.—Presetting flareless-tube assembly.

(distance (Z)) should be approximately as listed in table 3-2. These figures will vary with wall thickness for a given size.

2. A slight collapse of the inner diameter of the tube at the sleeve cut and at the shoulder is permissable.

3. The sealing surface of the sleeve must be smooth and free from nicks and scratches.

4. The sleeve should be slightly bowed and rotation of the sleeve is permitted. A 1/64-inch lengthwise movement of the sleeve is also permitted.

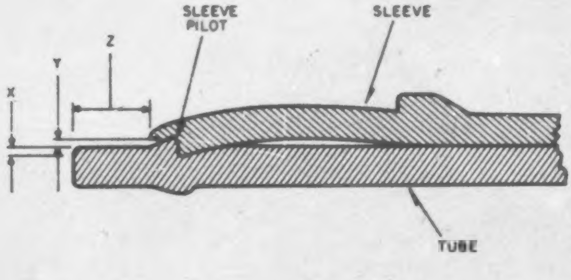
5. As a final check to determine that the fitting is properly preset, it should be proof tested at a pressure equal to twice the intended working pressure.

REMOVING OIL AND GREASE FROM OXYGEN TUBING ASSEMBLIES

Most raw tubing material is stored with a light film of protective oil applied to prevent surface corrosion. Following manufacture of tubing assemblies to be used in oxygen systems, they must be cleaned thoroughly to remove all traces of oil and grease. There are two methods of removing oil and grease:
Method A and Method B.

Method A consists of vapor degreasing the tubing assembly with stabilized trichloroethylene, which conforms to Military Specification O-T-634, Type 2. Proper cleaning is accomplished by allowing the complete tubing assembly to remain in a vapor degreaser unitl the specified temperature of the degreaser is reached. The tubing is then removed from the degreaser and blown clean and dry with a stream of clean, dry, water-pumped air.

Oil-pumped air must not be used as a substitute for the water-pumped air because oil vapor deposits would remain in the tubing.



AS.703

Figure 3-26.—Preset sleeve—flareless-tube fitting.

Table 3-2.—Distance from sleeve to tube end.

Tube size	Tube projection
3/16	7/64
1/4	7/64
5/16	5/32
3/8	11/64
1/2	3/16
5/8	13/64
3/4	7/32
1	15/64

Gaseous oxygen or clean water-pumped nitrogen may be used as a substitute for the water-pumped air.

Every precaution must be taken to insure that the tubing and its fittings are absolutely clean. After cleaning, the tubing should be treated with a brush coat of chemical film surface treatment (MIL-C-5541). Use of this chemical film is discussed in chapter 4.

If a vapor degreasing tank is not available method B is used to insure tubing cleanliness. This method consists of flushing the tubing with trichloroethylene conforming to Military Specification MIL-T-27602. The tubing is then blown clean and dry with water-pumped air followed by another flushing with anti-icing fluid conforming to Military Specification TT-I-735. Following the second flushing, the tubing is dried with a stream of clean, dry, water-pumped air or by heating at a temperature of 250° to 300°F or a suitable period of time. Following cleaning and drying, the tubing is chemically treated as specified in method A.

INSTALLATION OF TUBE ASSEMBLIES

Before a tubing assembly is installed in an aircraft, it should be carefully inspected. Dents and scratches should be removed (if possible without weakening the tube) prior to installation. The proper nuts and sleeves should be installed and a proper fit obtained where the tubing is flared. Flareless assemblies should be checked for proper presetting. Each tube assembly should be proof pressure tested to twice its operating pressure prior to installation. The tubing assembly should be clean and free from all foreign matter.

The nuts should be hand screwed to the mating connector, then tightened with the proper wrench. The tubing assembly should not have to be pulled into place with the nut, but should be properly aligned prior to tightening.

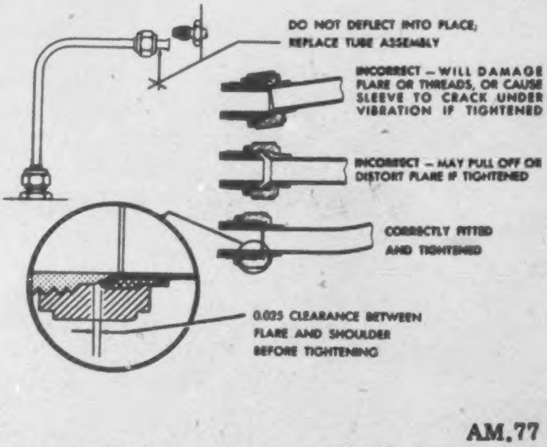
Tubing which runs through cutouts should be installed with care so that it will not be scarred when worked through the hole. If the tubing assembly is long, the edges of any cutouts should be taped before the tubing is installed.

It is important to tighten tube fitting nuts properly. A fitting wrench or open end wrench should be used when tightening tube connections. NOTE: Pliers should never be used to tighten tube connections.

Flared-Tube Assemblies

Correct and incorrect methods of installing flared-tube assemblies are illustrated in figure 3-27. Proper torque values are given in tables 3-3 and 3-4. It must be remembered that these torque values are for flared-tube fittings only.

If an aluminum alloy tube assembly leaks after tightening to the required torque, it must not be tightened further. Overtightening may severely damage or completely cut off the tubing flare or may result in damage to the sleeve or


DO NOT DEFLECT INTO PLACE; REPLACE TUBE ASSEMBLY
INCORRECT – WILL DAMAGE FLARE OR THREADS, OR CAUSE SLEEVE TO CRACK UNDER VIBRATION IF TIGHTENED
INCORRECT – MAY PULL OFF OR DISTORT FLARE IF TIGHTENED
CORRECTLY FITTED AND TIGHTENED
0.025 CLEARANCE BETWEEN FLARE AND SHOULDER BEFORE TIGHTENING

AM.77

Figure 3-27.—Flared fittings installed correctly and incorrectly.

Table 3-3.—Torque limits for flared-tube fittings (inch pounds).

Tube (OD) (inch)	B-Nut torque		
	TUBING		
	High pressure steel		Low pressure aluminum
	Steel nut (AN817)	Aluminum nut (AN818)	Aluminum nut (AN817&818)
3/16		80	28
1/4	125	105	50
5/16	160	160	78
3/8	230	230	112
1/2	430	430	200
5/8	700	700	312
3/4		1000	450
1			600

NOTE: AN 817 and AN 818 nuts are manufactured from steel and aluminum.

Table 3-4.—Torque values for double flared type coupling nuts (oxygen system fittings).

Tube OD (inch)	Torque (inch-pounds)	
	Working torque	Maximum torque
5/16	100	200
3/8	200	300
1/2	300	500

nut. The leaking connection should be disassembled and the fault corrected. Common faults are as follows:

1. Flare distorted into the nut threads.
2. Sleeve cracked.
3. Flare out of round.
4. Flare cracked or split.
5. Inside of flare rough or scratched.
6. Connector mating surface rough or scratched.
7. Threads of connector or nut dirty, damaged, or broken.

If a steel tube assembly leaks, it may be tightened 1/6 turn beyond the noted torque in an attempt to stop the leakage; then if unsuccessful it must be disassembled and repaired.

Undertightening of connections may be serious, as this can allow the tubing to leak at the connector because of insufficient grip on the flare by the sleeve. The use of a torque wrench will prevent undertightening. CAUTION: A nut should never be tightened when there is pressure in the line, as this will tend to damage the connection without adding any appreciable torque to the connection.

Flareless-Tube Assemblies

When installing flareless-tube assemblies, inspect to insure that no scratches or nicks are evident and that the sleeve is properly preset.

Lubricate the threads of the nuts and connectors with hydraulic fluid. Place the assembly in the proper position in the aircraft and finger tighten clamps, brackets, supports, and nuts. The tubing ends should fit snugly in the connectors and require little pressure to hold them in place. CAUTION: Hydraulic fluid must not be used to lubricate fluid line connections in oxygen systems.

Use the torque values that are listed in table 3-5. If it is not possible to use a torque wrench, follow this procedure for tightening nuts: Run the nut down tight, using the fingers if possible. If this is impossible, use a wrench but be alert for the first signs of bottoming. It is important that final tightening commence at the point where the nut just begins to bottom. With a wrench, tighten the nut 1/6 of a turn (one flat on hex nut).

After the tube assembly is installed, the system should be pressure tested. Should a connection leak, it is permissible to tighten the nut an additional 1/6 turn (making a total of 1/3 turn). If after tightening the nut a total of 1/3 turn, leakage still exists, the assembly should be removed and the components of the assembly should be inspected for scores, cracks, presence of foreign material, or damage from overtightening. NOTE: Overtightening a flareless-tube nut drives the cutting edge of the sleeve deeply into the tube, causing the tube to be weakened

Table 3-5.—Torque values for flareless fittings.

WRENCH TORQUE FOR 304 1/8 H STEEL TUBES

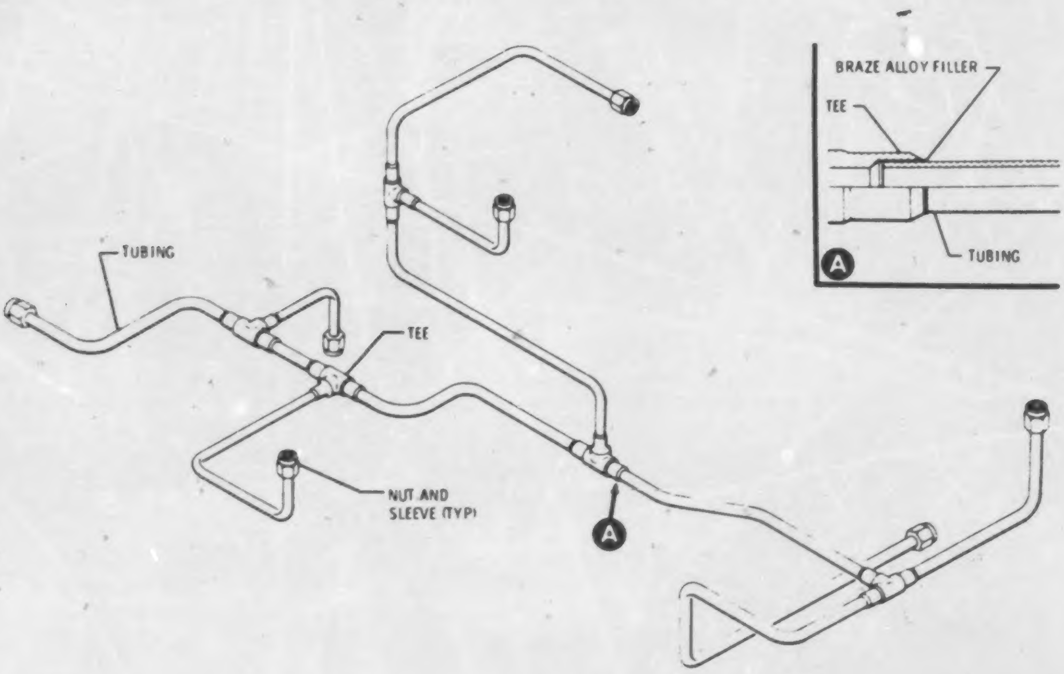
Tube outside diameter	Wall thickness	Wrench torque inch-pounds
3/16	0.016	90-110
3/16	0.020	90-110
1/4	0.016	110-140
1/4	0.020	110-140
5/16	0.020	100-120
3/8	0.020	170-230
3/8	0.028	200-250
1/2	0.020	300-400
1/2	0.028	400-500
1/2	0.035	500-600
5/8	0.020	300-400
5/8	0.035	600-700
5/8	0.042	700-850
3/4	0.028	650-800
3/4	0.049	800-960
1	0.020	800-950
1	0.065	1600-1750
WRENCH TORQUE FOR 304-1A or 3471A STEEL TUBES		
3/8	0.042	145-175
1/2	0.028	300-400
1/2	0.049	500-600
1	0.035	750-900
WRENCH TORQUE FOR 6061-T6 or T4 TUBES		
1/4	0.035	110-140
3/8	0.035	145-175
1/2	0.035	270-330
1/2	0.049	320-380
5/8	0.035	360-440
5/8	0.049	425-525
3/4	0.035	380-470
1	0.035	750-900
1 1/4	0.035	900-1100

to the point where normal in-flight vibration could cause the tube to shear. After inspection (if no discrepancies are found), reassemble the connections and repeat the pressure test procedures.

CAUTION: Do not tighten the nut beyond 1/3 turn (two flats on the hex nut); this is the maximum the fitting may be tightened without the possibility of permanently damaging the sleeve and tube.

Brazed Tube Assemblies

Brazed tubing systems are appearing in many of the later model aircraft within the Navy. The brazed tubing system includes a multibranch feature which results in fewer threaded connections and the near elimination of O-ring seals. A typical example of a brazed assembly is provided in figure 3-28. Brazed



AM.932

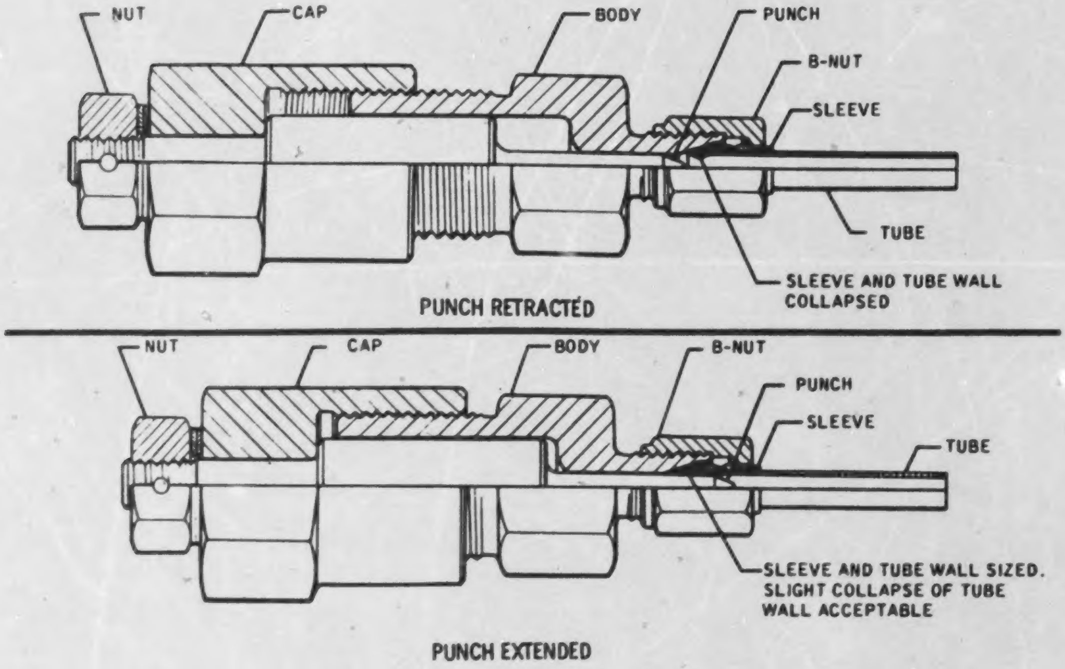
Figure 3-28.—Brazed tubing assembly.

tubing assemblies are made of rigid corrosion-resistant steel and assembled with sleeves and coupling nuts. Individual segments of the assembly are generally identified by separate part number and dash number and are brazed together into an assembly. On some aircraft such as the A-4F, a direction-of-flow arrow is electroetched on each individual segment of each tube assembly.

Maintenance of brazed tubing is limited to identification marking maintenance, sleeve sizing, segment repair, or complete assembly replacement. Tubing identification maintenance consists of installing color band tape on new tubing assemblies and on existing assemblies where the color bands have become lost, worn, or illegible. The requirements, location, and precautions for installing color band identification are covered in Structural Hardware, NavAir 01-1A-8.

Overtightening of the B-nut on the flareless type fitting used to connect most brazed tubing assemblies usually results in damage to the sleeve and consists of a necking down or swaging of the tip. This necking down can usually be corrected by the use of a sleeve sizing punch assembly as illustrated in figure 3-29. Because of the malleability of the sleeve material, sizing can be accomplished several times before the prospect of material failure would require replacement of that segment.

SLEEVE SIZING.—The sleeve sizing procedure can be accomplished without removing the line assembly from the aircraft, space permitting. Disconnect the tube assembly and connect the B-nut on the end of the tube assembly to the threaded part of the body on the punch assembly fingertight. Using a wrench to hold the body, tighten the B-nut 1/6 turn (one hex side) beyond fingertight. Next, still holding the body of the punch assembly, slowly turn the cap on the punch assembly until the punch is bottomed in the extended position. Reverse the wrench action to withdraw the punch. Disconnect the punch assembly from the tube assembly and inspect the sleeve. Slight collapse of the tube assembly is permissible. No nicks or scoring marks are allowed on the sleeve, and no movement of of the sleeve except rotation is permissible.


NUT
CAP
BODY
PUNCH
B-NUT
SLEEVE
TUBE
SLEEVE AND TUBE WALL COLLAPSED
PUNCH RETRACTED
NUT
CAP
BODY
B-NUT
PUNCH
SLEEVE
TUBE
SLEEVE AND TUBE WALL SIZED. SLIGHT COLLAPSE OF TUBE WALL ACCEPTABLE
PUNCH EXTENDED

AM.934

Figure 3-29.—Sleeve sizing—flareless fitting.

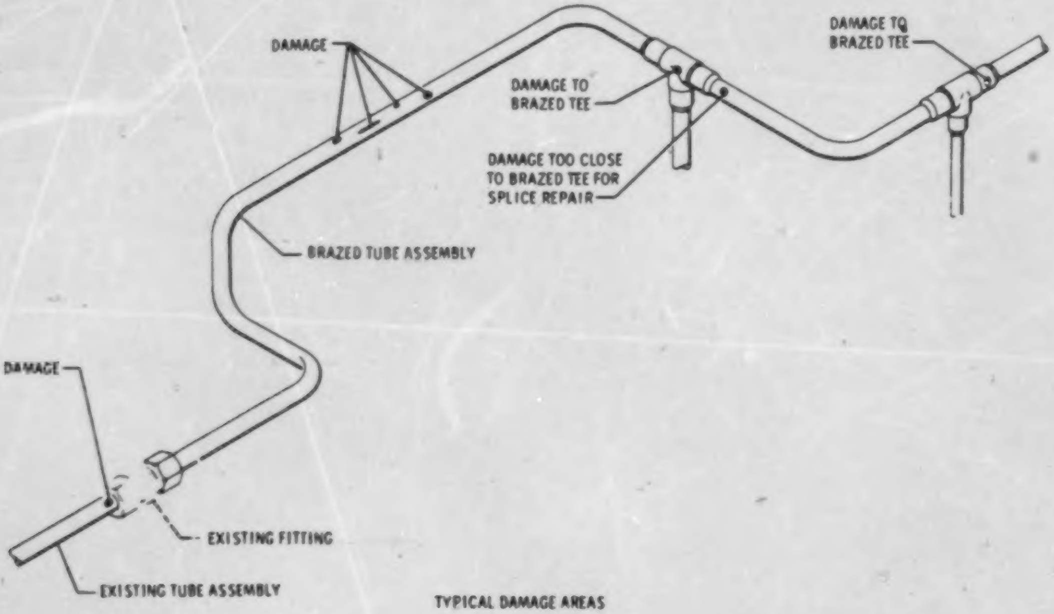
Pressure test the repaired assembly for leakage as specified in the applicable MIM. If the pressure test is positive, reconnect the tube assembly to the aircraft system, airbleed the lines, and service the system.

SEGMENT REPAIR.—Whenever a segment or a fitting of a brazed tubing assembly has been damaged, it can generally be repaired. Figure 3-30 provides an example of typical segment repairs to a damaged assembly. With all pressure relieved in the system to be repaired, disconnect all couplings. Cap or plug all openings on adjacent lines and components to prevent loss of fluid and/or entrance of contamination. Cap or plug all openings on the tube assembly except two, one at the highest and one at the lowest openings. Pour suitable solvent into the highest opening to remove all system residue. Connect 20 to 40 psi of air pressure upstream of any cutting, burring, and sleeve presetting operations and insure that the coupling downstream is open for purge air exit. Brazed oxygen tubing assemblies must be purged using clean, dry, water pumped air or nitrogen as specified in the MIM. This will prevent entry of metal particles in the system. The procedures for repair of such tubing assemblies may vary slightly in the various MIM's. Following repair, the assembly must be tested.

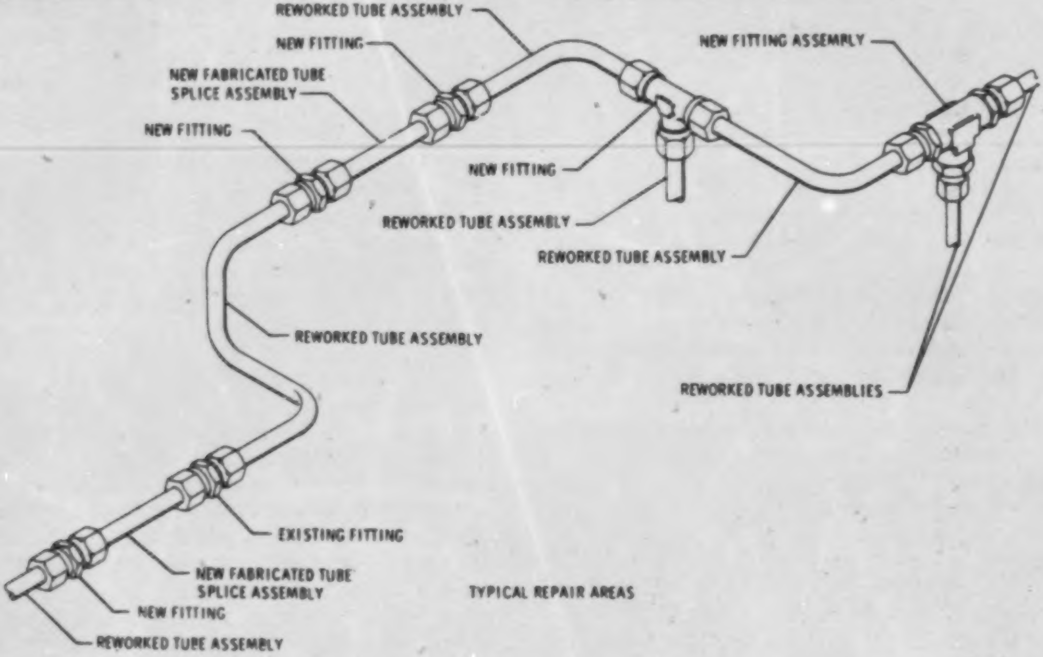
Oxygen System Tube Assemblies

Care must be taken at all times to keep the tubing clean and free from foreign matter during installation. The use of thread antisieze tape (polytetrafluroethylene—MIL-T-27730A) should be limited to tapered male pipe threads. Thread compounds or tape should not be used on oxygen flared tube fitting threads.

Thread antisieze tape (size 1 — 1/4 inch wide) is used on 1/8, 1/4, and 3/8 inch pipe threads. Thoroughly clean the male and female threads, assuring that all previously applied tape or compound is removed. Wrap the antisieze tape in the direction of the spiral of the male pipe threads, beginning with the third thread. If maximum tolerance diameter female fittings are


DAMAGE
DAMAGE TO BRAZED TEE
DAMAGE TO BRAZED TEE
DAMAGE TOO CLOSE TO BRAZED TEE FOR SPLICE REPAIR
BRAZED TUBE ASSEMBLY
DAMAGE
EXISTING FITTING
EXISTING TUBE ASSEMBLY

TYPICAL DAMAGE AREAS


REWORKED TUBE ASSEMBLY
NEW FITTING
NEW FITTING ASSEMBLY
NEW FABRICATED TUBE SPLICE ASSEMBLY
NEW FITTING
NEW FITTING
REWORKED TUBE ASSEMBLY
REWORKED TUBE ASSEMBLY
REWORKED TUBE ASSEMBLY
REWORKED TUBE ASSEMBLIES
EXISTING FITTING
NEW FABRICATED TUBE SPLICE ASSEMBLY
NEW FITTING
REWORKED TUBE ASSEMBLY

TYPICAL REPAIR AREAS

AM.935

Figure 3-30.—Brazed tubing segment repair.

being mated with nominal or minimum tolerance male fittings, this will prevent the tape from being cut and entering the system.

If minimum tolerance diameter female fittings are being mated with maximum tolerance diameter male fittings, a very close fit will result and thread tape is applied from the first thread up. Care should be taken not to contaminate the tape. Completely encircle the threads and join the ends together with a very slight overlap.

Pipe threaded fittings should be started by hand. A torque wrench should be used to tighten all pipe threaded fittings. The torque values for pipe threaded connections are listed in table 3-6.

CAUTION: The importance of the following cannot be overemphasized: It is imperative that all oxygen equipment, lines, and fittings be kept free from GREASE, DIRT, OIL, HYDRAULIC FLUID, and LEAKS. Leakage in oxygen system connections should be eliminated since the leakage rate may increase with time and vibration.

FLEXIBLE HOSE

Flexible hose is used in connecting moving parts with stationary parts and in locations subject to severe vibration. It is heavier than aluminum alloy tubing and deteriorates rapidly; therefore, it is used only where absolutely necessary. The two types, rubber and Teflon flexible hose, are discussed in the following paragraphs.

RUBBER

Flexible rubber hose consists of a seamless synthetic rubber inner tube covered with layers of cotton braid and wire braid, and an outer layer of rubber impregnated cotton braid. It is provided in low-pressure, medium-pressure, and high-pressure types. Figure 3-31 illustrates the hose which is commonly used in medium-pressure applications. This hose is identified by a Military Specification number, the hose size, the quarter year and year of manufacture, and the hose manufacturer's symbol. This information is stenciled on the hose at intervals of not more than 9 inches the entire length of the hose. The stenciled information indicates the natural lay of the hose.

Table 3-6.—Torque values for pipe threaded fittings (oxygen system).

Pipe thread (inch)	Torque (inch-pounds)
1/8	125 - 175
1/4	200 - 300
3/8	300 - 450

The size of flexible hose is determined by the inside diameter (ID) and indicated by a numbering system identical to that used with rigid tubing. Therefore, the fittings used on No. 6 hose will be the same size and have the same threads as those used on No. 6 (3/8 inch) tubing.

High-pressure hose is available to the operating activity in complete assemblies only. These assemblies are equipped with swaged type fittings and are fabricated only by commercial activities and intermediate or depot maintenance level activities, because of the special tools required. Medimum- and low-pressure hose assemblies are equipped with detachable type end fittings (described later) and may be fabricated at the intermediate maintenance level.

FABRICATION AND REPLACEMENT

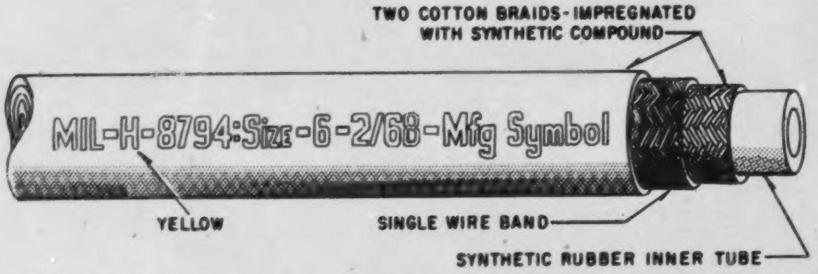
Flexible hose must be replaced if peeling, flaking of the hose cover, or exposure of the fabric reinforcement to the elements occur.

When failure occurs in a flexible hose equipped with swaged end fittings, the unit is generally replaced without attempting a repair; that is, the correct length of hose, complete with factory-installed end fittings, is drawn from supply.

When failure occurs in low-pressure or medium-pressure hose equipped with detachable type end fittings, the replacement unit is usually fabricated in the shop. Undamaged end fittings on the old length of hose may be removed and reused; otherwise, new fittings must be drawn from supply along with a sufficient length of hose.

NOTE: Inspect bulk hose prior to use to insure that its shelf life has not expired. The shelf life of bulk rubber hose should not exceed 5 years (20 quarters) from the date of manufacture (cure date). The cure date is normally stenciled on the hose as shown in figure 3-31.

Figure 3-32 illustrates one type of detachable end fitting. This fitting is intended for use with medium-pressure hose which conforms to


TWO COTTON BRAIDS-IMPREGNATED WITH SYNTHETIC COMPOUND
MIL-H-8794:Size-6-2/68-Mfg Symbol
YELLOW
SINGLE WIRE BAND
SYNTHETIC RUBBER INNER TUBE

AM.79

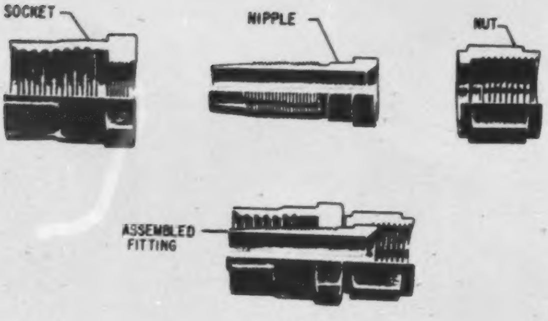
Figure 3-31.—Medium-pressure hose.

Specification MIL-H-8794C. This fitting is designed for use in flared-tube systems. Other hose fittings which are designed to be used with flareless-tube fittings are also available.

Assembly of Sleeve Type Fittings

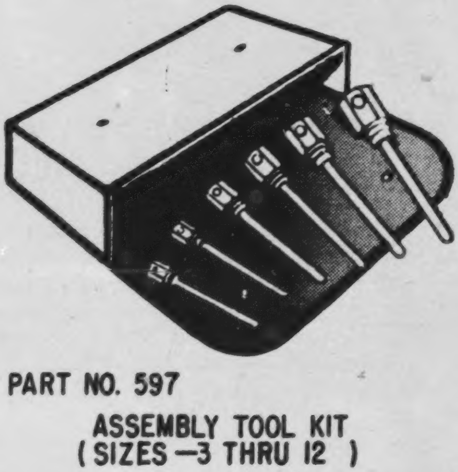
A tool kit is available for assembling the MS-24587 fittings to MIL-H-8794C (medium-pressure) hose. Figure 3-33 illustrates the hose assembly tool kit, which contains the assembly tools for use on the smaller sizes (3/16 through 3/4 inch) of hose. If a tool kit is not available, the corresponding size AN-815 adapter may be used.

Figure 3-34 illustrates the steps in assembling the MS-24587 fitting, using the proper size assembly tool from the hose assembly tool kit.


SOCKET
NIPPLE
NUT
ASSEMBLED FITTING

AM.80

Figure 3-32.—Sleeve type flexible hose fitting (MS-24587).


PART NO. 597
ASSEMBLY TOOL KIT
(SIZES —3 THRU 12)

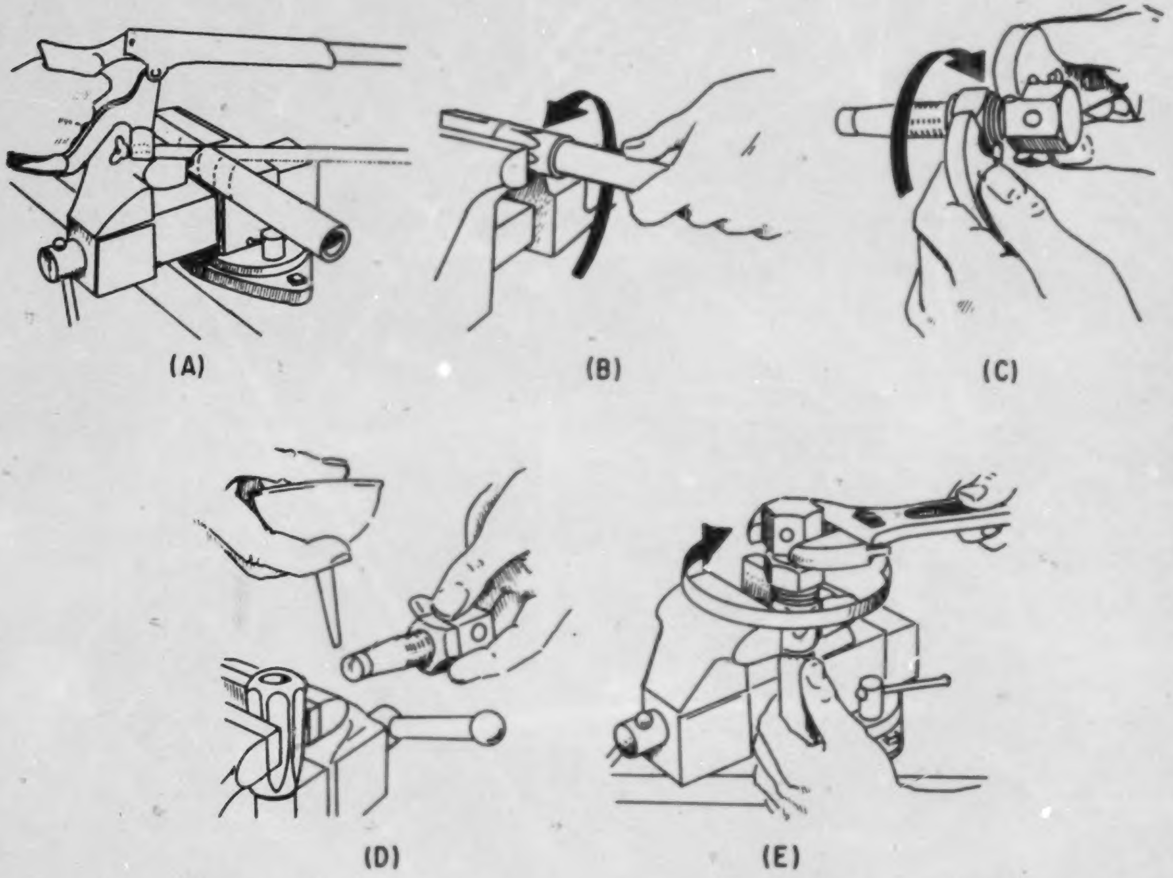
AM.81

Figure 3-33.—Medium-pressure hose assembly tool kit.

After assembly, always make sure all foreign matter is removed from the inside of the hose by blowing out with compressed air.

All shop-assembled flexible hose must be proof tested after assembly. Proof testing is accomplished by plugging or capping one end of the hose and applying pressure to the inside of the hose assembly.

Proof testing of shop fabricated hose assemblies should be accomplished in accordance with instructions contained in the applicable Maintenance Instructions Manual. In cases where proof test pressures are not included in the aircraft



A. Clamp the hose in the vise and cut the required length with a fine-tooth hacksaw.

B. Secure the socket in the vise. Turn the hose counterclockwise into the socket until it bottoms. Unscrew 1/4 turn.

c. Insert the nipple in the nut. Install the proper size assembly tool and tighten, using two wrenches.

D. Place the socket in the vise with the threaded end exposed. Lubricate the inside of the hose and the nipple threads with hydraulic fluid or light lubricating oil.

E. Using a wrench on the assembly tool, screw the nipple into the socket and hose, exercising care to prevent the hose from turning. A clearance of 1/32 to 1/16 inch between the nut and socket is required so that the nut will swivel. Remove the assembly tool.

Figure 3-34.—Assembly of MS-24587 fitting to medium-pressure flexible hose.

Maintenance Instructions Manual, refer to the Aircraft Structural Hardware Manual, NavAir 01-1A-8. Table 3-7 lists the proof test pressures for a few sizes of medium-pressure hose when assembled with MS-24587 fittings for use in aircraft hydraulic systems.

Installation of Flexible Hose Assemblies

Flexible hose must not be twisted on installation, since this reduces the life of the hose considerably and may cause the fittings to loosen

Table 3-7.—Proof test pressures for medium-pressure hose assembled with MS-24587 fittings.

Hose size number	Operating pressure (psi)	Proof pressure (psi)	Burst pressure (psi)
4	3,000	6,000	12,000
5	3,000	5,000	10,000
6	2,000	4,500	9,000
8	2,000	4,000	8,000
10	1,750	3,500	7,000
12	1,500	3,000	6,000

as well. Twisting of the hose can be determined from an identification stripe running along its length, or as in the case of medium-pressure hose (shown in figure 3-31) by the stenciled information that is used to identify the hose.

The minimum bend radius for flexible hose varies according to size and construction of the hose and the pressure under which the hose will operate. Tables and graphs showing minimum bend radii for all types of installations are provided in Aircraft Structural Hardware, NA-01-1A-8. Bends which are too sharp will reduce the bursting pressure of flexible hose considerably below its rated value.

Flexible hose should be installed so that it will be subject to a minimum of flexing during operation. Hose must be supported at least every 24 inches. Closer supports are desired.

A flexible hose must never be stretched tight between two fittings. About 5 to 8 percent of its total length must be allowed as slack to provide freedom of movement under pressure. When under pressure, flexible hose contracts in length and expands in diameter.

TEFLON

Teflon hose is a flexible hose designed to meet the requirements of higher operating temperatures and pressures in present-day weapon systems. Teflon hose can generally be used in the same manner as rubber hose.

Teflon hose consists of a tetrafluorethylene resin which is processed and extruded into tube shape to a desired size. It is covered with stainless steel wire which is braided over the tube for strength and protection. The advantages of this hose are its operating temperature range (-67° F to + 450° F), its chemical inertness to all fluids normally used in hydraulic and engine lubrication systems, and its long life. At this time, only medium-pressure and high-pressure types are available and are complete assemblies with factory-installed end fittings. These fittings may be either the detachable type or the swaged type. When failures occur, replacement must be made on a complete assembly basis.

The size of Teflon hose is determined in the same way the size of rubber hose is determined.

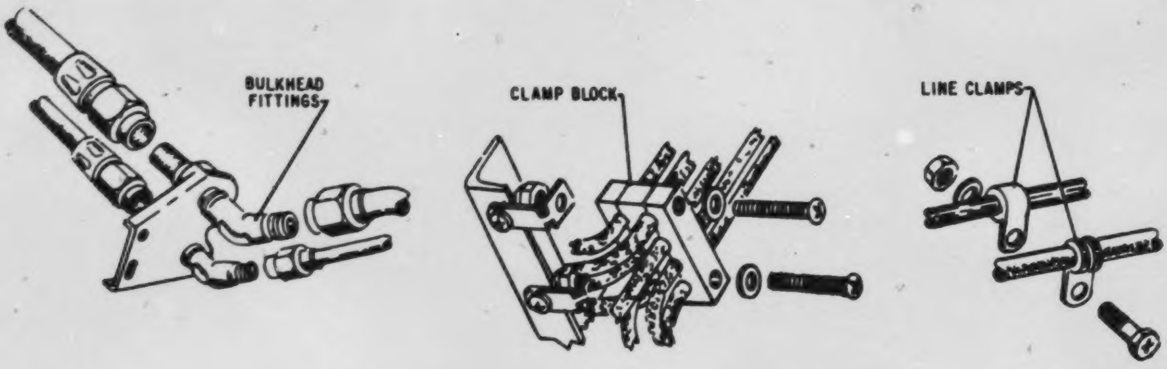
Teflon hose, like rubber hose, has definite limits and particular characteristics that demand understanding and attention in the general handling during installation and removal. To insure its satisfactory function and reduce the likelihood of failure, the following rules should be observed when working with Teflon hose:

1. Do not exceed recommended bend limits.
2. Do not exceed twisting limits.
3. Clamp the hose assemblies at least every 24 inches (more closely if possible) to lend support enough to prevent bending and kinking.
4. Do not permit flexible hose to impinge on, and thus possible deflect, rigid supporting lines.
5. Allow a slight slack in the hose line to accommodate changes in length that will occur when pressure is applied.
6. Do not straighten a bent hose that has taken a permanent set.
7. Do not hang, lift, or support objects from Teflon hose.

Maintenance

Teflon hose, like all aircraft parts, has definite wearability limits. The chafing caused by hose rubbing against other surfaces, for instance, has undermined many parts and systems. Disaster consequent to such wear can be averted only through frequent inspection and maintenance by alert maintenance and quality assurance personnel.

INSPECTION.—Whereas all rubber aircraft hose must be inspected for aging and associated



AM.415

Figure 3-35.—Methods used to secure fluid lines.

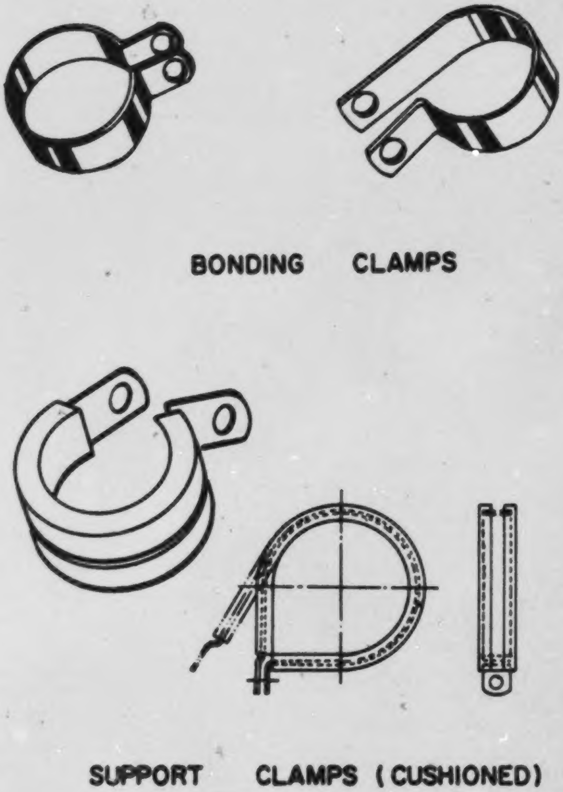
deterioration immediately prior to installation, Teflon hose, being comparatively inert, is exempt from shelf-life control. However, Teflon hose assemblies must be visually inspected for leakage, abrasion, and kinking according to the aircraft inspection requirements in the applicable Maintenance Instructions Manuals. The presence and extent of the following possible defects must be determined.

Kinking.—Kinking is an imperfection induced in Teflon when it is bent at a closer angle (or shorter radius) than its characteristics allow. This is a common cause of failure, because Teflon hose tends to assume the shape of the position in which it is installed and becomes semipermanently set or "preformed" in these configurations. These so-called preformed hoses kink easily and their walls are severely weakened if they are excessively bent or twisted or if they are permitted to follow their natural tendencies to revert to their orientations. They must be handled very carefully while being removed and should be tied with wire that will hold them in shape pending reinstallation.

Excessive Cold Flow.—Cold flow is the name given the deep permanent impressions and cracks in the hose cover caused by the pressure of the hose clamps. Replace hose when cold flow becomes too deep.

Weather-Checking.—Weather-checking, the occurence of numerous fine cracks caused by exposure to various weather conditions over extended periods, causes no serious damage as long as it does not expose the fabric of the hose cover. However, weather-checking deepened to the point of exposing this fabric can contribute to the weakening and eventual failure of hose.

To examine the extent of weather-checking, flatten the walls of the hose together, with force if necessary. If the cord fabric can be seen at



AM.78

Figure 3-36.—Bonding and support clamps.

any point, replace the hose. Replace the hose also if radial cracks at the end of the hose are deeper than one-eighth inch or are halfway from the ends of the hose to the clamps.

Internal Cracking.—Fuel hoses, both Teflon and rubber, dry out and crack when they lose the plasticizer that keeps them pliable. Hoses remain pliable while in active use with gasoline flowing through them but lose their plasticizers when the fuel is drawn off.

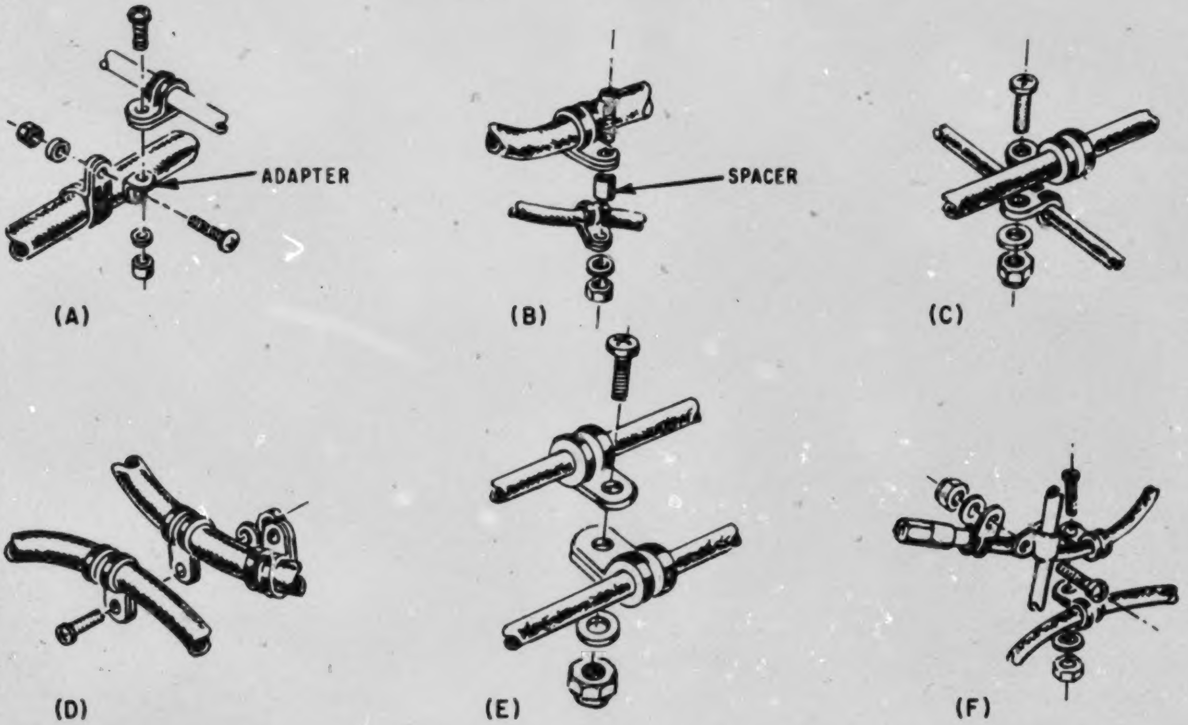
Therefore, fuel lines of previously used aircraft that are to be returned to service after extended storage must be inspected for internal cracking. Those showing internal cracks, which are best revealed by pressing the hose with the fingers to widen imperfections, should be replaced, while those showing no visible cracks at either end are considered satisfactory throughout.

Separation of Outer Cover.—When the cotton-braid or rubber coverings of metal-reinforced hose become loose, frayed, or chafed to the point that the metal reinforcement is exposed or damaged, replace the hose. If a hose shows some wear but the metal is not exposed or damaged, wrap the frayed or chafed areas in flexible, electrical-insulation sleeving and secure it over the hose with support clamps.

Wire-Braid Damage.—Wire-braid damage is considered excessive when two or more wires in a single plait or six or more in an assembly (or lineal foot when assemblies are longer than 12 inches) are broken. Broken wires, where kinking of Teflon hose is suspected, are felt as sharp dents or twists in the braid.

CAUTION: When performing wire-braid damage check, the Teflon hose must always be handled with great care so that the wire-braid damage does not not injure the hands.

CLEANING.-Teflon hose is nonabsorbent and nonadhesive, and is usually unaffected by fuels, lubricating oils, coolants, and solvents used around aircraft. It is easily cleaned in oleum spirits, kerosene, trichloroethylene, or synthetic detergents. When dipped in or flushed with the cleaning solution, the hose merely



AM.416

Figure 3-37.—Securing lines using support clamps.

needs a slight brushing to remove the surface debris.

WARNING: Because some solvents are highly flammable and some toxic, proper precautions must be taken when they are used. Prolonged inhalation of fumes must be avoided.

STORAGE.—When storing Teflon hose, be sure to:

1. Cap or plug the ends of all hose assemblies with metal or plastic plugs.
2. Tape hose ends to prevent wire flareout.
3. Store hose in straight position if possible. When it is necessary to coil hose, use the widest coil possible.

CLAMPS

As stated earlier in this chapter there are hundreds of feet of tubing and flex hose running throughout the aircraft structure. These fluid lines are routed to follow the configuration of the aircraft structure to provide support for the lines. Clamps, bulkhead fittings, clips, brackets, and clamp blocks not only secure the lines to the adjacent structure, but also provide a dampening effect to prevent harmful vibration. Fluid lines must be kept separated from the aircraft structure and other lines to prevent chafing. Chafing (rubbing) of the lines can cause failure of the system. As the lines rub against each other or the aircraft structure, the wall thickness of the tubing is diminished until it can no longer withstand the fluid pressure, and the line ruptures. The three most common methods of securing fluid lines are shown in figure 3-35.

INSTALLATION OF CLAMPS

While performing maintenance actions the AME may be required to remove clamps and/or clamp blocks. In all cases, unless directed by Aircraft Changes, Bulletins, etc., the clamp (s) and/or clamp block(s) with all of the necessary hardware (washers, spacers, nuts, screws and/or bolts) must be reinstalled.

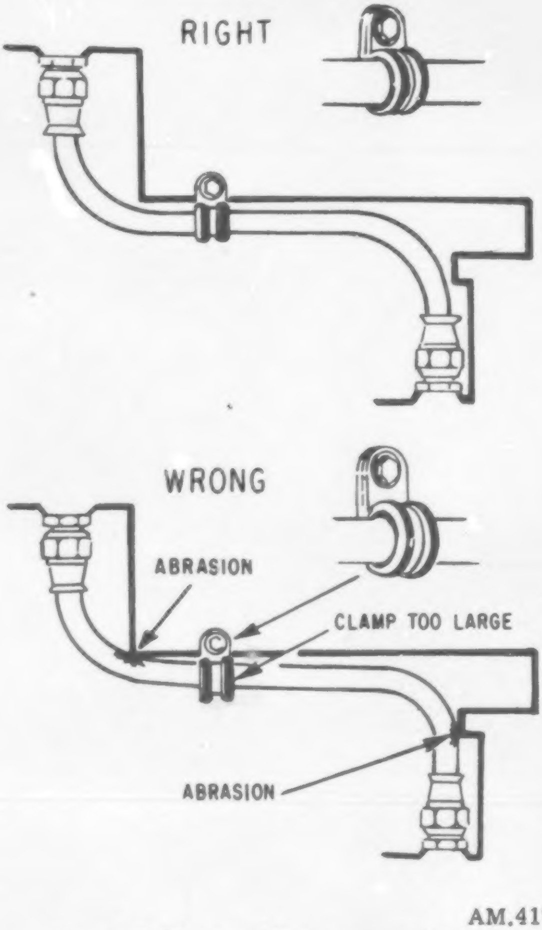
CAUTION: Do no allow any dropped hardware to remain lying in the aircraft upon completion of maintenance actions.

The most abused and neglected are the line clamps which are used to properly bond (provide a path for static electricity) and support rigid tubing and flexible hose. Figure 3-36 shows both the plain bonding clamps and the cushioned steel clamp. The cushioning material may be either rubber or Teflon.

Support clamps should be installed at 15-inch intervals and as close to tubing bends as possible. In no case should clamps be installed at intervals greater than 20 inches.

When tubing is connected to a structure or other tubing, a minimum clearance of 1/16 inch should be maintained. A minimum clearance of 1/4 inch should be maintained between lines and moving parts that are actuated on the aircraft. Extra support clamps may be used in any installation to prevent vibration and chafing, or to provide line clearance.

Figure 3-37 illustrates six ways to secure fluid lines to each other using support clamps



AM.417

Figure 3-38.—Installation procedures (right and wrong.)

maintain line clearance and prevent chafing e to vibration. In view (A) an adapter is used maintain the desired line clearance. View (B) strates the use of a spacer, and views (C), , (E), and (F) show the use of support clamps positioned in such a manner as to separate the fluid lines properly.

Figure 3-38 shows a flexible hose secured to the aircraft structure. The lower view shows what could happen if too large a clamp were used.

CHAPTER 4

CORROSION CONTROL

CORROSION

Modern high-speed aircraft are dependent upon the structural soundness of the metals which make up the largest percentage of their thousands of parts. The greatest threat to structural integrity of naval aircraft is metals corrosion. With higher strength demands being made of aircraft metals and the closer tolerances of flight safety demanded, these aircraft would rapidly become inoperative without regular anticorrosion attention.

Corrosion endangers the aircraft by reducing the strength and changing the mechanical characteristics of the materials used in its construction. Materials are designed to carry certain loads and withstand given stresses as well as to provide an extra marging of strength for safety. Corrosion can weaken the structure, thereby reducing or eliminating this safety factor. Replacement or reinforcement operations are costly, time-consuming, and reduce usage of the aircraft. Severe corrosion can cause failure of parts or systems which is an obvious danger. Corrosion in vital systems can cause malfunctions that endanger the safety of flight, and such dangers reemphasize the importance of corrosion control.

Metals corrosion is the deterioration of metals as they combine with oxygen to form metallic oxides. This combining is a chemical process which is essentially the reverse of the process of smelting the metals from their ores. Very few metals occur in nature in the pure state. For the most part they occur naturally as metallic oxides. These oxides may also be mixed with other undesirable impurities in the ores. The refining processes generally involve the extraction of relatively pure metal from its ore and addition of other elements (either metallic or non-metallic) to form alloys. Alloying constituents are added to base metals to develop a variety of useful properties. For example, in aircraft structural applications, high strength-to-weight ratios are the most desirable properties in all alloys.

After refining, regardless of whether or not alloyed, base metals possess a potential or tendency to return to their natural state. However, potential is not sufficient in itself to initiate and promote this reversion. There must also exist a corrosive environment, in which the significant element is oxygen. It is the process of oxidation—combining with oxygen—that causes wood to rot or burn and metals to corrode.

Control of corrosion is dependent upon maintaining a separation between susceptible alloys and the corrosive environment. This separation is accomplished in various ways. A good intact coat of paint provides almost all of the corrosion protection on naval aircraft. Sealants are used at seams and joints to prevent entry of moisture into the aircraft, preservatives are used on unpainted areas of working parts, and shrouds, covers, caps, and other mechanical equipment provide varying degrees of protection from corrosive media. None of these however, provide 100 percent protection in the long run—paint is subject to oxidation and decay through weathering; sealants may work out by vibration or else be eroded by rain and windblast. Preservatives at best offer only temporary protection when used on operating aircraft and the mechanical coverings are subject to improper installation and neglect. Control of corrosion properly begins with an understanding of the causes and nature of this phenomenon. Corrosion is caused by electrochemical or direct chemical reaction of a metal with other elements. In the direct chemical attack, the reaction is similar to that which occurs when acid is applied to bare metal. Corrosion in its most familiar form is a reaction between metal and water and is electrochemical in nature.

In the electrochemical attack, metals of dif- erent electrical potential are involved and they eed not be in direct contact. When one metal ontains positively charged ions and the other egatively charged ions and an electrical con- uctor is bridged between them, current will low as in the discharge of a dry cell battery. n electrochemical corrosion the conductor ridge may be any foreign material such as ater, dirt, grease, or any debris that is capable f acting as an electrolyte. The presence of salt n any of the foregoing mediums tends to accel- rate the current flow and hence speed the rate f corrosive attack.

Once the electrical couple is made, the elec- ron flow is established in the direction of the egatively charged metal (cathode), and the ositively charged metal (anode) is eventually estroyed. All preventive measures taken with espect to corrosion control are designed pri- narily to avoid the establishment of the elec- rical circuit, or secondly, to remove it as soon s possible after establishment before serious amage can result. Figure 4-1 illustrates the lectron flow in a corrosion environment (elec- rolyte) resulting in destruction of the anodic rea. Note that the surface of a metal, especially lloys of the metal, may contain anodic and athodic areas due to impurities or alloying onstituents which have different potentials than he base metal.

Electrochemical attack is evidenced in sev- ral forms, depending upon the metal involved, ts size and shape, its specific function, atmos- heric conditions, and the type of corrosion- roducing agent (electrolyte) present. There are nany forms of metals deterioration resulting rom electrochemical attack about which a great eal is known. But despite extensive research nd experimentation, there is still much to be earned about other, more complex and subtle orms. Descriptions are provided later in this hapter for the more common forms of corro- ion found on airframe structures.

Since there are so many factors which con- ribute to the process of corrosion, selection of naterials by the aircraft manufacturer must be nade with weight versus strength as a primary onsideration and corrosion properties as a econdary consideration. In the interest of aero- ynamic efficiency, even the number of drain oles is limited until accumulated operational ata indicates a greater drain requirement. lose attention during aircraft design and roduction is also given to heat treating and annealing procedures, protective coatings, choice and application of moisture barrier materials, dissimilar metals contact, and access doors and plates. In other words, every logical precaution is taken by the aircraft manufacturers to inhibit the onset and spread of corrosive attack.

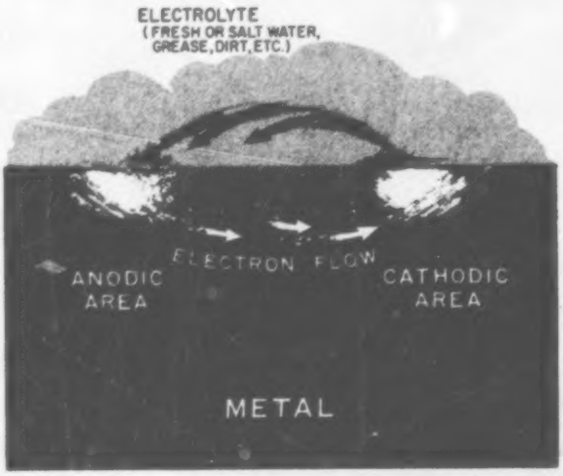


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Figure 4-1.—Simplified corrosion cell.

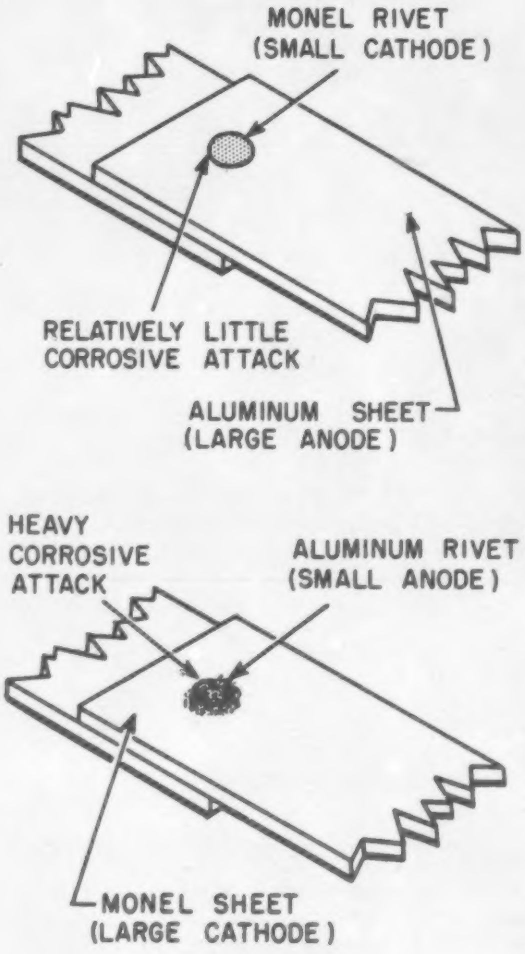
There are many factors that affect the type, speed, cause, and the seriousness of metal corrosion. Some of these corrosion factors can be controlled; others cannot. Preventive maintenance factors such as inspection, cleaning, and painting and preservation are within the control of the operating squadron. They offer the most positive means of corrosion deterrence.

The electrochemical reaction which causes metal to corrode is a much more serious factor under wet, humid conditions. The salt in sea water and the salt in the air is the greatest single cause of aircraft corrosion. Hot climates speed the corrosion process because the electrochemical reaction develops fastest in a warm solution, and warm moisture in the air is usually sufficient to start corrosion if the metals are uncoated. As would be expected, hot dry climates usually provide relief from constant corrosion problems. Extremely cold climates produce corrosion problems if a salt atmosphere is present. Melting snow or ice provides the necessary water to begin the electrochemical reaction.

Thick structural sections are subject to corrosive attack because of possible variations in their composition, particularly if they were heat treated during fabrication. Similarly, when large sections are machined or cut out after heat treatment, thinner sections have different physical characteristics than the thicker areas. In most cases, difference in physical characteristics provides enough difference in electrical potential to render the piece highly susceptible to corrosion. Another corrosion factor regarding size of materials lies in the area relationship between dissimilar metals. When two dissimilar metals are used where possible contact may develop, if the more active metal is small, compared to the less active one, corrosive attack will be severe and extensive if the insulation should fail. If the area of the less active metal is small compared to the other, anodic attack is relatively slight. Figure 4-2 illustrates this factor.

One of the biggest problems in corrosion control is in knowing what materials to use, where to find them, and the limitations applicable to their use. Materials used should be those covered and controlled by military specifications, preferably those authorized specifically for use on aircraft. Corrosion control information pertaining to materials, methods, and techniques is scattered throughout many directives and instructions, and this information is constantly being revised as better chemicals and protective methods are developed. The following is a list of sources of information that should be readily available for reference in every unit's technical library or in the airframes shop:

1. Aircraft Cleaning and Corrosion Control for Organizational and Intermediate Maintenance Levels, NavAir 01-1A-509.
2. Preservation of Naval Aircraft, NavAir 15-01-500.
3. Chart—Cleaning Materials for Naval Air Systems—Maintenance and Overhaul Operations, NavAir 07-1-503.
4. Chart—Corrosion Preventive Compounds used by the Naval Air Systems Command, NavAir 01-1A-518.
5. Corrosion Control, Cleaning, Painting, and Decontamination.



AM. 50

Figure 4-2.—Effects of area relationships in dissimilar metal contacts.

One volume of the Maintenance Instructions Manuals for all late model aircraft is on these subjects.

6. Periodic Maintenance Requirements Cards (as applicable).

PREVENTIVE MAINTENANCE

"An ounce of prevention is worth a pound of cure." Where corrosion prevention on naval aircraft is concerned the foregoing cliche is a diculous understatement. Compared with the ost of some late model aircraft, which runs ito millions of dollars, the cost of corrosion revention is a mere pittance. Preventive main-enance is a powerful tool which can be used to ffectively control even the most difficult cor-osion problems.

Most corrosion prevention programs are ad-isted by the operating activity to meet severe onditions aboard ship and then decreased in cope when the aircraft is returned to the rel-tively mild conditions prevailing ashore. When egular corrosion preventive maintenance must e neglected in emergencies due to tactical perating requirements, a period of intensive are should follow in order to bring the air-raft back up to standard.

Preventive measures most commonly taken ith respect to corrosion require the aircraft be kept as clean as possible, all surface nishes intact, correct and timely use of covers nd shrouds, periodic lubrication, and the appli-ation of preservatives where required. Years experience have proven the need for such easures if the aircraft are to remain air-orthy.

Where corrosion preventive maintenance is eglected, aircraft soon become unsafe to fly. quadrons with the best corrosion preventive rograms are likely to have the best safety ecords, most utilization of aircraft, and lowest perating costs.

URFACE MAINTENANCE

Surface maintenance includes regular clean-g of the aircraft as well as touchup of protec-ve paint coatings. Since paint touchup is ac-omplished after removal of corrosion, overage on this subject is included under the eading, Corrosion Elimination, later in this hapter. This does not imply that touchup of amaged paint should not be done unless cor-osion is present. Touchup of new damage to aint finishes will prevent corrosion from start-g there.

The cleaning of aircraft is an important func-on in retaining the aerodynamic efficiency and afety of aircraft. In keeping with this impor-ance, acceptable materials, methods, and pro-edures for use in aircraft maintenance cleaning re prescribed in current directives and must e used. Instances of serious damage have re-ulted to exterior and interior of aircraft due the lack of correct information regarding materials and equipment and their use. Shipboard procedures are not necessarily the same as procedures ashore, but the same materials are available and comparable results are accomplished, although different application methods may be necessary.

How often an aircraft should be cleaned depends on the type of aircraft and the environment in which it has been operating. It is important that the aircraft be kept in a clean condition and repeated cleaning should be accomplished as often as necessary. The necessity for cleaning is indicated whenever there is any appreciable amount of soil accumulation within exhaust track areas; by the presence of salt deposits or other contaminants such as stack gases; by evidence of paint surface deterioration such as softening, flaking, or peeling; and by the presence of excessive oil or exhaust deposits or spilled electrolyte and deposits around batttery areas. Cleaning is always mandatory immediately after exposure to fire extinguishing materials, after exposure to adverse weather conditions and salt spray, after the aircraft has been parked near seawalls during high wind conditions, after low level flight, and after repairs or service which has left stains, smudges, or other gross evidence of maintenance. A daily cleaning or wipedown is required on all exposed unpainted surfaces such as struts, actuating cylinder rods, etc.

Aircraft must be thoroughly cleaned before being placed in storage and should also receive a thorough cleaning at the time of depreservation. Unpainted aircraft are cleaned and also polished at frequent intervals. Aboard ship, cleaning and removal of salt deposits are necessary as soon as possible to prevent corrosion.

Components which are critically loaded (designed with minimum safety margins to conserve size and weight) such as helicopter rotor parts, and components and parts which are exposed to corrosive environments, such as engine exhaust gas, acid, or rocket blast, are cleaned as often as possible to minimize exposure to these corrosive agents. NOTE: Lubrication and preservation of exposed components are necessary to displace any of the cleaning solution entrapped during the cleaning operation.

Materials

Only NavAir specification cleaning materials may be used on aircraft. Navy specification cleaning materials are made up and compounded to accomplish definite results and are made available only after complete testing and actual field acceptance. All specification materials are inspected and tested before acceptance and delivery to the supply activities. Cleaning agents commonly used by Organizational and Intermediate maintenance activities are included in the following categories.

SOLVENTS.–Solvents are liquids which dissolve other substances. There are a great number of different solvents, but for cleaning purposes, organic solvents are most often used. Some solvents are chlorinated. When solvents contain more than 24 percent by volume of chlorinated materials they must be kept in specially marked containers and care must be taken to insure that equipment in which these solvents are used are designed and operated as to prevent the escape of such solvents, as a liquid or vapor, into the workroom.

All personnel occupied with or working near chlorinated solvents should be particularly careful to avoid breathing the vapors. While the vapors from some solvents are more toxic than others, prolonged breathing of the fumes can be injurious to health.

In addition to the breathing hazard associated with solvents, they also present varying degrees of fire and explosion hazards, depending upon the material. It is considered that solvent cleaners having a flashpoint greater than 105° F are relatively safe. Those having flashpoints below 105° F require explosion proofing of equipment and other special precautions when using them. (The flashpoint is the temperature at which the first flash from the material is seen, as an open flame is passed back and forth over a sample of flammable liquid being heated in a cup.)

Another hazard associated with solvents, and to a certain extent with all cleaning materials, is the effect on the surface or material being cleaned. Some solvents will deteriorate rubber, synthetic rubber, asphaltic coverings, etc. This is such an important consideration that it must always be taken into account when selecting cleaning materials. It may do a good job in removing dirt, grease, oil, exhaust gas deposits, etc., but may also damage the object being cleaned or soften and ruin otherwise good paint coatings.

Solvent, Drycleaning.–This material is a petroleum distillate commonly used in aircraft cleaning. It is furnished in two types, I and II. Type I material, commonly known as Stoddard solvent, has a flashpoint slightly above 100° F. Type II has a higher (safer) flashpoint and is intended for shipboard use.

In naval aviation maintenance, Stoddard solvent (type I) is used as a general all-purpose cleaner for metals, painted surfaces, and fabrics. It may be applied by spraying, brushing, dipping, and wiping. This material is preferable to kerosene for all cleaning purposes because kerosene leaves a light oily film on the surface.

Mineral Spirits.–This is another liquid petroleum distillage which is used as an all-purpose cleaner for metal and painted surfaces and as a diluting material for emulsion compounds, but is not recommended for fabrics. Like Stoddard solvent, it may be applied by spraying, brushing, dipping, and wiping.

Aliphatic Naphtha.–This is an aliphatic hydrocarbon product used as an alternate compound for cleaning acrylics and for general cleaning purposes that require fast evaporation and no remaining film residue. It may be applied by dipping and wiping. Saturated surfaces must not be rubbed vigorously, as it is a highly volatile and flammable solvent with a flashpoint below 80° F. Avoid prolonged breathing and skin contact. Use in well-ventilated areas only.

Aromatic Naphtha.–This is a petroleum aromatic distillate. This naphtha is a bare-metal cleaner and is also used for cleaning primer coats before applying lacquer. It will remove oil, grease, and light soils. It is also highly flammable and reasonably toxic. Avoid prolonged breathing and skin contact. CAUTION: Do not use aromatic naphtha on acrylic surfaces as it will cause crazing.

Safety Solvent.–Methyl chloroform is intended for use where a high flashpoint and less toxic solvent than carbon tetrachloride is required. It is used for general cleaning and grease removal of assembled and disassembled engine components in addition to spot cleaning, but should not be used on painted surfaces. Safety Solvent is not suitable for oxygen systems although it may be used for other cleaning in ultrasonic cleaning devices. It may also be applied by wiping, scrubbing, or booth spraying. The term Safety Solvent is derived from the high flashpoint. Many later issue maintenance manuals label safety solvent as Trichlorethane 1,1,1.

Methyl Ethyl Ketone (MEK).–This material is used as a cleaner for bare-metal surfaces.

It is not miscible to any great extent with water but is a diluent for lacquers. It is applied with wiping cloths or soft bristle brushes over small areas at a time.

WATER EMULSION CLEANERS.–Emulsion cleaners tend to disperse contaminants into tiny droplets which are held in suspension in the cleaner until they are flushed from the surface. Water emulsion compound conforming to MIL-C-22543 contains emulsifying agents, coupling agents, detergents, solvents, corrosion inhibitors, and water. It is intended for use on painted and unpainted surfaces in heavy duty cleaning operations where milder specification materials of lower detergency would not be effective. It is used in varying concentrations, depending on the condition of the surface. A concentration of 1 part compound to 4 parts water, by volume, is recommended for heavier soiled surfaces. For mildly soiled surfaces, the concentration is changed to 1 part compound to 9 parts water, by volume. Starting at the bottom of the area being cleaned, apply the mixed solution by spraying or brushing to avoid streaking. Loosen surface soils by a mild brushing or mopping and follow with a thorough fresh water rinse. The automatic shutoff type water spray nozzle is best for rinsing. It gives hand control from a light mist or fogging spray to a full spray with high-pressure water.

ALKALINE WATERBASE CLEANING COMPOUND.–This compound is similar to the water emulsion cleaner. It is a general purpose cleaner used to remove light to moderate soils. It is a detergent type cleaner composed of wetting agents and surface active agents. It is mixed in 1 part compound to 9 parts water for light soils and 1 part compound to 3 parts water for removing medium soils. It may be applied to the surface by mopping, wiping, spray equipment, or foam producing equipment. It is safe for use on fabrics, leather, glass, ceramics, and transparent plastics. Follow the previously described procedure for washing the aircraft and rinse thoroughly with fresh water before the compound dries to prevent streaking.

SOLVENT EMULSION CLEANERS.–This cleaner, conforming to Specification P-C-444, is intended for heavy duty cleaning and should be used with caution around painted surfaces as it will soften paint if in contact with the paint finish very long. It will remove paralketone and similar corrosion preventive coatings and should not be used on parts thus protected unless it is desired that such protective coatings be removed. For heavy cleaning, the cleaning compound is mixed in a concentration of 1 part compound to 4 parts of drycleaning solvent (Stoddard solvent). For lighter duty use, it can be mixed at a 1 to 9 ratio.

WATERLESS CLEANER.–This compound is intended for use on painted and unpainted aircraft surfaces in heavy duty cleaning operations where water for rinsing is not readily available or where freezing temperatures do not permit the use of water. It is relatively nontoxic, noncorrosive, nonflowing gel or cream, and its detergent properties enable it to be used as an effective agent for the removal of grease, tar, wax, carbon deposits, and exhaust stains. It should not be applied to canopies or other acrylic plastic surfaces. It is safe for use as a waterless hand cleaner.

MECHANICAL CLEANING MATERIALS.–Mechanical cleaning materials such as abrasive papers, polishing compounds, polishing cloths, wools, wadding, etc., are available in the supply system for use as needed. However, their use must be in accordance with the cleaning procedures outlined in NavAir 01-1A-509, the specific aircraft Maintenance Instructions Manual, and directions supplied with the material being used if damage to finishes and surfaces is to be avoided. In cases of conflicting information, NavAir 01-1A-509 will always take precedence.

Aluminum Oxide Paper.–Aluminum oxide paper (300 grit or finer) is available in several forms and is safe to use on most surfaces since it does not contain sharp or needlelike abrasives which can embed themselves in the base metal being cleaned or in the protective coating being maintained. The use of carborundum (silicon carbide) papers as a substitute for aluminum oxide paper should be avoided. The grain structure of carborundum is sharp, and the material is so hard that individual grains can penetrate and bury themselves even in steel surfaces.

Powdered Pumice.–This material is similar to Bon Ami which may also be used. The pumice is used as a slurry with water and is applied to the surface with clean rags and bristle brushes.

Impregnated Cotton Wadding.–Cotton which has been impregnated with a cleaning material is used for the removal of exhaust gas stains and for polishing corroded aluminum surfaces. It is also used on other metal surfaces to produce a high reflectance.

Aluminum Metal Polish.–Aluminum metal polish is used to produce a high-luster, long-lasting polish on unpainted aluminum-clad surfaces. It is not used on anodized surfaces as it will remove the oxide coat.

Aluminum Wool.-Three grades of aluminum wool-coarse, medium, and fine-are stocked for general abrasive cleaning of aluminum surfaces.

Lacquer Rubbing Compound, Type III.-For the removal of engine exhaust residues and minor oxidation, lacquer rubbing compound, Type III, may be used. Heavy rubbing over rivet heads or edges where protective coatings may be thin should be avoided as the coverings may be damaged most eaily at these points.

Cleaning Equipment

The cleaning of aircraft not only requires the use of correct cleaning materials, but also the use of properly maintained equipment to produce efficient and satisfactory results. A specific cleaning area should be prepared and equipped for performing cleaning operations.

The choice of equipment depends on several factors, such as the amount of cleaning that is regularly performed, the type of aircraft that is being cleaned, the location of the activity, and the availability of facilities such as air pressure, water, and electricity.

Several specialized items of equipment are available for cleaning aircraft. These include pressure type tank sprayers, a variety of spray guns and nozzles, high-pressure cleaning machines, and industrial type vacuum cleaners.

One of the latest devices for faster and economical cleaning of aircraft is a swivel type conformable applicator cleaning kit developed by the 3M Company. Officially designated Scotch-Brite Conformable Applicator Cleaning Kit No. 251, it is designed to clean aircraft exteriors several times faster than using cotton mops or bristle brushes.

The applicator head of the cleaning kit is curved and flexible to conform readily to convex and concave aircraft exteriors. A swivel joint on the back of the applicator head provides further flexibility. The 5 x 7 inch Scotch Brite cleaning and polishing pad attaches easily to the applicator head and provides a more aggressive and efficient scrubbing medium than bristle fibers. It can be used without fear of scratching aluminum or painted surfaces.

The swivel and applicator head are attached to a standard brush handle. The excellent conformability of the applicator allows easier application of a constant scrubbing pressure on curved skin panels and eliminates the need for a maintenance stand to keep brushes in maximum contact with the surface.

Some larger shore activities maintain a self-contained vehicle Flight Line Maintenance Master for use of all tenant activities. The Fight Line Maintenance Master is self-propelled and self-contained. It provides a heated soap solution with its own water system. It has a 1,000-gallon capacity and is equipped with an extendable boom to accommodate cleaning of high horizontal and vertical stabilizers.

The cleaning solution is sprayed at high pressure from the boom or ground level positions or both positions simultaneously. Control of the boom and cleaning solution can be made from the boom or the vehicle cab. The maneuverability of the vehicle makes it extremely efficient in cleaning all exterior aircraft surfaces. Brushing of surfaces can be easily accomplished by the boom operator. The ground hose is equipped with a crank rewind and is 50 feet long. The boom is equipped with floodlights to accommodate nighttime use of the vehicle. As with other support equipment, the maintenance master should only be operated by qualified and licensed personnel. In some cases specialized equipment must be manufactured locally by the activity, otherwise it is procured through regular supply channels.

In addition to the specialized equipment mentioned above, other items such as hoses, brushes, sponges, and wiping clothes are required for aircraft cleaning. These items are procured through supply.

Items of personal protection such as rubber gloves, rubber boots, goggles, and aprons should be worn when necessary to protect clothing, skin, and eyes from fumes and splashing of caustic materials.

Cleaning Methods and Procedures

The first step in cleaning the aircraft is selecting the proper cleaning agent for the method of cleaning to be used. The recommended type cleaning agent for each method, including instructions and precautions to be observed in their use, may be found in NavAir 01-1A-509 and the applicable Maintenance Instructions Manual for the type of aircraft being cleaned.

The next step is the preparation of the aircraft for cleaning. Ground the aircraft to the deck after spotting it in a cool place if possible. If the aircraft has been heated while parked in the sun or areas of the aircraft are heated as a result of operations, it should be cooled before the start of cleaning by the use of fresh water washdown. Many cleaning materials will clean faster at elevated temperatures, but the risk of damage to paint, rubber, and plastic surfaces is increased by the cleaners which are concentrated by the rapid solvent evaporation caused by the high temperatures. Static electricity generated by the cleaning operation will be dissipated through the ground wire. After securing all the obvious openings such as canopies and access panels, further secure the aircraft against entry of water and cleaning compounds as necessary. Mask or otherwise cover all equipment or components that can be damaged by moisture or the cleaning agent being used.

WATER RINSE CLEANING.—The water rinse method is recommended as the most efficient and satisfactory method of cleaning aircraft when they are only lightly contaminated with loosely adhering soils and water soluble corrosion products. The aircraft is prepared as previously outlined, and all materials and equipment that will be required during the cleaning are ascertained to be on hand and ready for use. The proper washing procedure to insure complete coverage is illustrated and described in figure 4-3. Apply water by progressing upward and outward, scrubbing briskly with a long handled fiber cleaning brush as necessary while the water is being applied. Do not scrub a dried surface. After scrubbing, rinse the surface from the top downward with a high-pressure stream of water until all the water soluble residues and loosened soils have been completely flushed off the aircraft.

WATER EMULSION CLEANING.—The emulsion cleaning method is used to clean aircraft contaminated with oil, grease, or other foreign matter which cannot be easily removed by other methods. The aircraft is prepared in the same manner as it was for the water rinse method.

Wet down the surface to be cleaned with fresh water. Apply a concentrated solution of 1 part emulsion compound cleaner to 4 parts of water to the heavily soiled areas that will normally require such a strong solution. Scrub these areas and allow the concentrated solution to remain on the surface. Limit the size of the area being cleaned to that size which can be easily cleaned while keeping the surface wet.

Next apply a diluted solution of emulsion compound and water, mixed to a ratio of 1 part emulsion compound to 9 parts water, to the entire surface to be cleaned including those areas previously covered with the concentrated solution. Scrub the surfaces thoroughly and allow the solution to remain on the surfaces 3-5 minutes before rinsing. Rinse from the top downward until all soils have been removed. If a high-pressure stream of water is used for rinsing, hold the nozzle at an angle and a reasonable distance from the surface being sprayed.

If any areas are still not clean, repeat the operation in those areas only. After rinsing, the aircraft may be dried with a clean sponge or cloths to insure against streaking that could be caused by emulsion cleaning. Normally, if the aircraft is thoroughly rinsed, streaking will be held to a minimum.

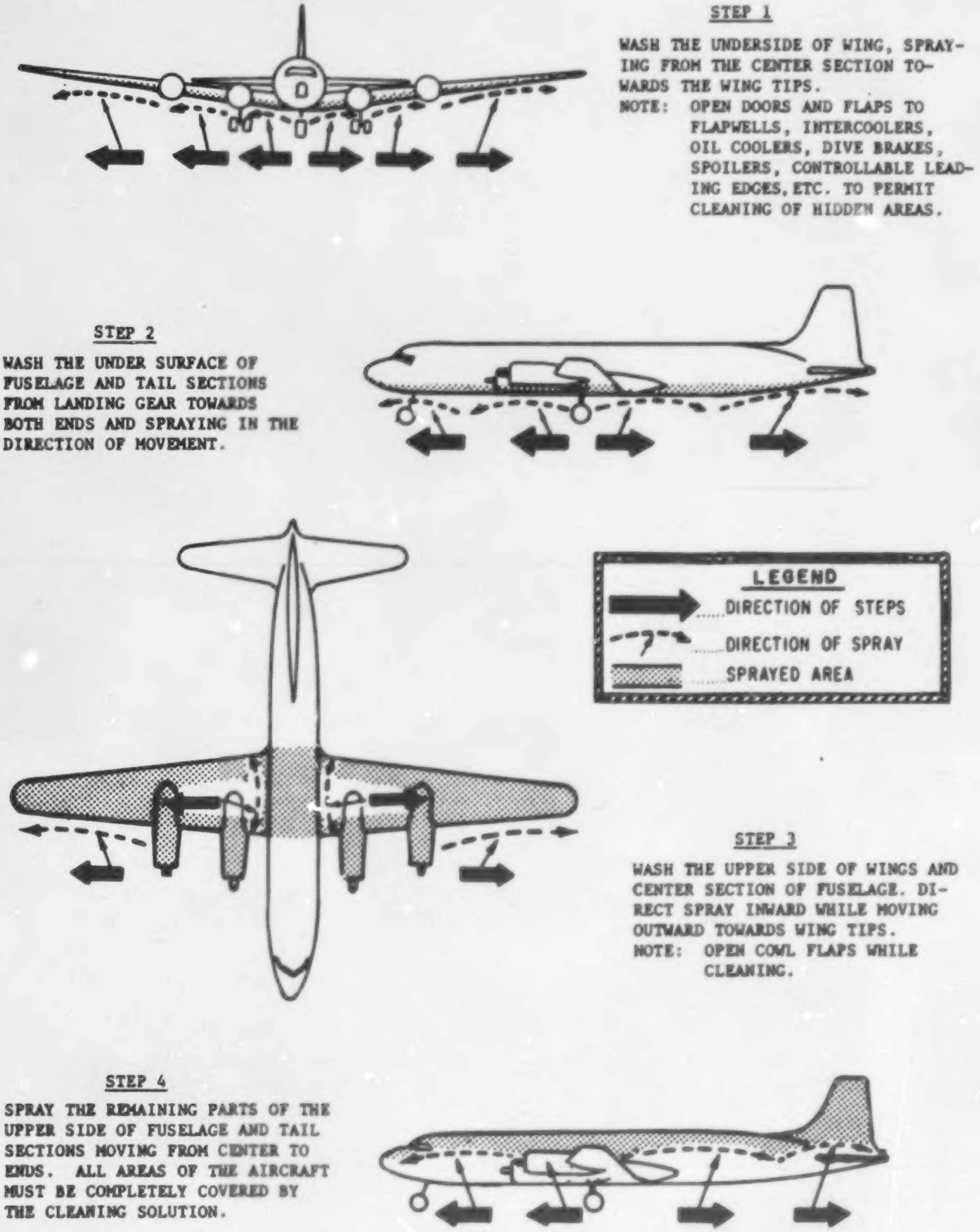
SOLVENT-EMULSION CLEANING.—Solvent-emulsion cleaning is intended for cleaning heavily soiled unpainted surfaces and parts and for use in removing corrosion preventive coatings. The cleaning compound is mixed in a concentration of 1 part compound to 9 parts of drycleaning solvent or mineral spirits. The solution is applied to a water-free surface, otherwise the water would lessen the solvent action. Since this cleaner will remove thick preservative materials, it should be used with care to prevent unwanted removal of such coatings.

The solution is applied by brush or with a high-pressure spray using a nozzle that gives a coarse fan-shaped spray. Scrub the surface with a brush as the solution is being applied. Allow the solution to remain on the surface long enough to loosen the soil without drying. Reapply and rescrub the more difficult soiled areas as necessary. Rinse thoroughly, using a large volume of fresh water to remove all loose soils and cleaning compound.

SPOT CLEANING.—Light oily soiled surfaces may be spot cleaned by wiping these areas with a drycleaning solvent. The solvent is applied with a saturated wiping cloth. Brush or wipe the surface as necessary then wipe clean with a dry cloth, removing the solvent residue and loosened soil. The solvent wipe may leave a light residue which may be removed with soap and water followed by fresh water rinsing.

NOTE: Drycleaning solvent should not be used in oxygen areas or around oxygen equipment. The solvent is not oxygen compatible and will cause explosion and/or fire.

WATERLESS WIPEDOWN.—When water is not available, heavy soils and operational films may be removed by using waterless cleaner. The cleaner is applied by dipping a dampened



STEP 1

WASH THE UNDERSIDE OF WING, SPRAYING FROM THE CENTER SECTION TOWARDS THE WING TIPS.

NOTE: OPEN DOORS AND FLAPS TO FLAPWELLS, INTERCOOLERS, OIL COOLERS, DIVE BRAKES, SPOILERS, CONTROLLABLE LEADING EDGES, ETC. TO PERMIT CLEANING OF HIDDEN AREAS.

STEP 2

WASH THE UNDER SURFACE OF FUSELAGE AND TAIL SECTIONS FROM LANDING GEAR TOWARDS BOTH ENDS AND SPRAYING IN THE DIRECTION OF MOVEMENT.

STEP 3

WASH THE UPPER SIDE OF WINGS AND CENTER SECTION OF FUSELAGE. DIRECT SPRAY INWARD WHILE MOVING OUTWARD TOWARDS WING TIPS.

NOTE: OPEN COWL FLAPS WHILE CLEANING.

STEP 4

SPRAY THE REMAINING PARTS OF THE UPPER SIDE OF FUSELAGE AND TAIL SECTIONS MOVING FROM CENTER TO ENDS. ALL AREAS OF THE AIRCRAFT MUST BE COMPLETELY COVERED BY THE CLEANING SOLUTION.

AM.51

Figure 4-3.—Aircraft washing procedures.

cloth into the creamlike waterless cleaning material and then spreading the material thinly over the area to be cleaned. Scrub the surface until the soil and cleaner become intermixed or emulsified. Allow the material to remain on the surface approximately 10 minutes; scrub and wipe off thoroughly with a clean wiping cloth. Make sure all soils and cleaning material are removed, exercising special care around fasteners and unsealed areas. In freezing weather a dry applicator should be used in lieu of a dampened one.

Post-cleaning Requirements

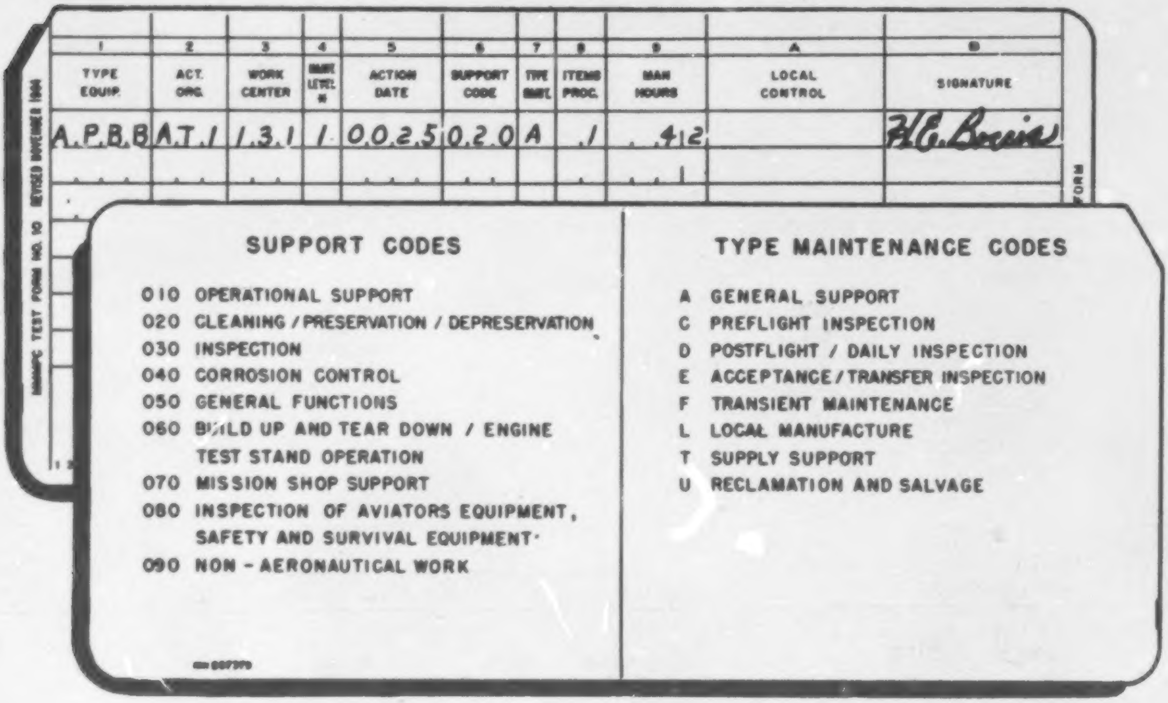
Following cleaning, the aircraft should be relubricated in accordance with the Maintenance Requirements Cards. Insure that all low-point drains are open. Apply aircraft preservatives as required to those clean, exposed unpainted surfaces. The types of preservatives are discussed later in this chapter. Insure that the felt wiper washers on all hydraulic cylinders are moistened with hydraulic fluid and that all exposed strut and actuating cylinder rods are wiped down with a clean rag saturated with hydraulic fluid. Remove any damaged or loosened sealant and replace in accordance with the applicable Maintenance Instructions Manual or Structural Repair Manual.

Figure 4-4 illustrates the documentation of a Support Action Form (SAF) utilized to account for the time spent cleaning an aircraft. The spaces 1 through 9 and A and B are self-explanatory and should be filled in accordingly. For detailed instructions on the SAF and its uses, consult Military Requirements for Petty Officer 3 & 2, NavPers 10056-C, or OpNav 4790.2.

NOTE: If the cleaning is done after normal working hours, on Saturday, Sunday, or declared holidays and the activity concerned is required to record manhour data, a Manhour Accounting (MHA) Card must be submitted in addition to the SAF.

USE OF COVERS AND SHROUDS

Each aircraft, when delivered by the manufacturer, is equipped with a complete set of



[illegible] TEST FORM NO. 10 REVISED NOVEMBER 1964

1	2	3	4	5	6	7	8	9	A	B
TYPE EQUIP.	ACT. ORG.	WORK CENTER	MAINT. LEVEL #	ACTION DATE	SUPPORT CODE	TYPE MAINT.	ITEMS PROC.	MAN HOURS	LOCAL CONTROL	SIGNATURE
A.P.B.B	A.T.1	1.3.1	1	0.0.2.5	0.2.0	A	.1	.412		H.E. Bossie

FORM

SUPPORT CODES

010 OPERATIONAL SUPPORT
020 CLEANING / PRESERVATION / DEPRESERVATION
030 INSPECTION
040 CORROSION CONTROL
050 GENERAL FUNCTIONS
060 BUILD UP AND TEAR DOWN / ENGINE TEST STAND OPERATION
070 MISSION SHOP SUPPORT
080 INSPECTION OF AVIATORS EQUIPMENT, SAFETY AND SURVIVAL EQUIPMENT
090 NON - AERONAUTICAL WORK

TYPE MAINTENANCE CODES

A GENERAL SUPPORT
C PREFLIGHT INSPECTION
D POSTFLIGHT / DAILY INSPECTION
E ACCEPTANCE / TRANSFER INSPECTION
F TRANSIENT MAINTENANCE
L LOCAL MANUFACTURE
T SUPPLY SUPPORT
U RECLAMATION AND SALVAGE

AM.6

Figure 4-4.—SAF documentation for cleaning aircraft.

tailored dust and protective covers. A typical set of covers is shown in figure 4-5 installed on an A-6A.

All covers and shrouds should be installed in such a manner that free drainage is assured. Do not create a bathtub which will trap and hold water. Shrouds or covers may also act as a greenhouse in warm weather and cause collection and condensation of moisture underneath. They should be loosened or removed and the aircraft ventilated on warm sunny days. Where protection from salt spray is required aboard carriers, the covers should be left in place and the aircraft ventilated only in good weather. Fresh water condensate will do far less damage than entrapped salt spray.

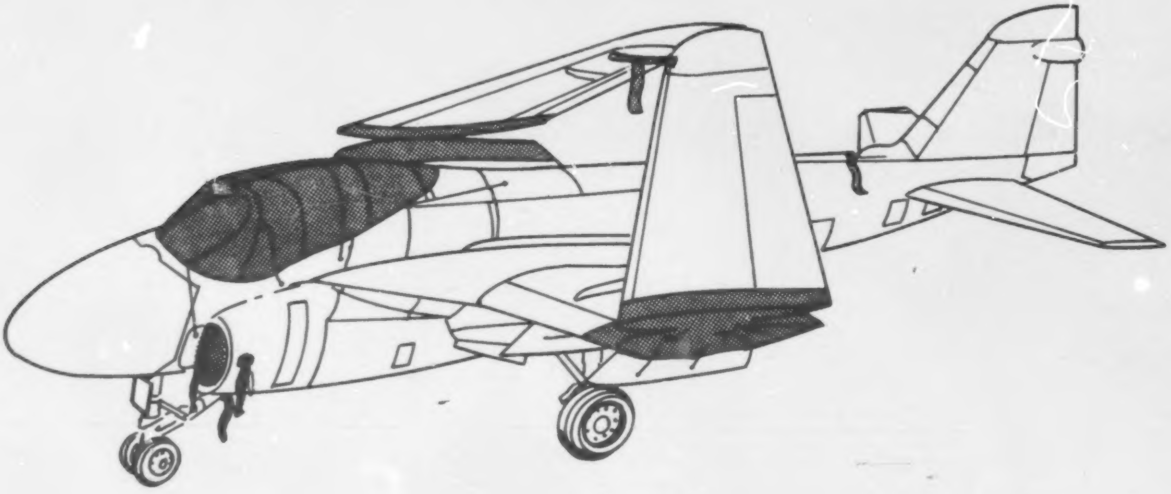
In emergencies where regular waterproof canvas covers are not available, suitable covering and shrouding may be accomplished by using polyethylene sheet, polyethylene coated cloth, or metal foil barrier material, all of which are available in the Navy supply system. These covers should be held in place with adhesive tapes designed specifically for severe outdoor application. The tapes are also available in supply.

GROUND HANDLING REQUIREMENTS

Maintenance Instructions Manuals for aircraft usually provide brief and simple ground handling procedures which, if observed, can do much toward reducing corrosive attack. Little things like heading the aircraft into the wind and installing available covers, battens, shrouds, etc., to keep water, salt, and dirt out of areas difficult to get at and easy to overlook, can save a tremendous amount of maintenance work later.

There are many other commonsense practices which should be observed to minimize paint damage and the loss of built-in protective systems during normal ground handling of the aircraft. Much damage is done to aircraft paint films by failure to use the tiedown points provided, or by passing tiedown cables and lines over or around supporting structures in such a manner that the paint finish is worn, chipped, or broken, especially at sharp edges.

Painted aircraft surfaces will withstand a normal amount of foot traffic and abrasion by fuel hoses and air lines. However, shoe soles and fueling hoses pick up bits of sand, gravel, and metal chips and become a coarse abrasive which scratches and scuffs the protective finish to the point where it is rendered completely ineffective under shipboard operating conditions. For this reason, time should be taken to wipe or brush the sand or gravel from shoe soles before climbing on aircraft.



AM.52

Figure 4-5.—A-6A dust and protective covers.

When removing cowling and access plates during inspections the removed hardware should not be placed on the deck to blow around and become scratched. If it is not practical to provide pads or cushioning for these components, they should at least be secured to prevent their movement. When using handtools to remove screws and quick-opening fasteners on the aircraft exterior, particular care should be taken to avoid scratching the paint. Five minutes of extra time spent in careful use of tools could save hours of paint touchup and corrosion removal work later.

AIRCRAFT PRESERVATION

The susceptibility of an aircraft to corrosion damage is greatest during those periods when the aircraft is dirty, inactive, or being shipped. Since aircraft spend more time on the ground than in the air, even in an active squadron, the need for effective protection becomes apparent.

Suitable protection against corrosive attack is achieved essentially by placing a barrier between the cleaned surface that is to be protected and any possible source of moisture. During manufacture or overhaul of the aircraft, protective barriers such as electroplate, paint, or chemical surface treatment are provided. Surfaces that cannot be so treated, and in some instances the treated surfaces themselves, must be covered with special corrosion-preventive compounds. The protection these compounds give is effective only if no moisture, dirt, or active corrosion is present on the treated surface. It is essential, therefore, that the aircraft be thoroughly clean and dry before a preservative compound is applied. It is also necessary that an unbroken film of preservatives be applied in as moisture-free an atmosphere as practicable.

Compounds alone do not provide complete protection. Tapes, barrier paper, and sealing devices must also be used to seal off the numerous openings on aircraft which, if allowed to remain open during long-time storage, would permit the entry of moisture and dirt. To provide additional protection against corrosion a complete moisture barrier is sometimes provided. Internal areas that have been sealed off are dehydrated by installing desiccants (moisture absorbents) to remove entrapped moisture unless the cavity is protected with a vapor corrosion inhibitor. When any area cannot be sealed adequately, provision must be made for ventilation and moisture drainage.

When certain installed equipment in an aircraft is not being used regularly, its components are required to be preserved. For example, the guns of an aircraft must be cleaned after each firing. The type of oil or other protective treatment which is to be applied subsequently depends upon the anticipated period of idleness for the guns.

The requirements for the preservation of operating aircraft are of the most concern of a Third or Second Class AME; therefore, this section emphasizes the use of preservative coatings to supplement paint films, prevent salt spray and salt water damage to operating aircraft, and minimize exposure during routine maintenance and repair.

In maintenance of aircraft surfaces, under operating conditions, preservation means supplementing the protection already present, or providing temporary protection to damaged areas, by the use of various protective coatings and barrier materials. A brief description of some of the more common materials used in aircraft preservation and readily available in Navy stock is included in the following paragraphs.

Compound, Corrosion-Preventive, Solvent Cutback

This material is familiarly known as "paralketone." It is supplied in four grades for specific application. All grades of this compound may be applied by brush, dip, or spray. They may be easily removed with Stoddard Solvent or mineral spirits. These materials are designed for cold application. Some preservative compounds must be applied hot; therefore, when intending to use one of the grades of this solvent cutback material, the specification number (MIL-C-16173) should always be verified.

Grade 1 forms a dark, hard-film, opaque cover. Its general use is limited because of the difficulty in removing aged coatings and also because of the hiding power of the material when it is applied over corroded areas. This material is used only where maximum protection against salt spray is required. Present instructions generally limit its use to seaplanes and amphibian surfaces.

Grade 2 is a soft-film, grease type material that can be used on most operating parts. Its chief disadvantage is the fact that it may be washed off under direct exposure to salt water or may be removed by inadvertent wiping. It protects under relatively severe conditions and, given adequate maintenance and touchup as necessary, can be used for most maximum protection requirements.

Grade 3 is a very light, water-displacing preservative, with the ability of penetrating under surface water and forming a protective film on the metal. This material is most effective in treatment of equipment or components after direct exposure of critical surfaces to water or firefighting chemicals, or for internal protection of water-carrying systems. This grade itself offers only limited protection for short periods of time and must be supplemented by frequent maintenance or heavier materials as soon as practicable.

Grade 4 preservative forms thin, semitransparent films through which identification data can usually be read. It also sets up relatively dry to the touch so that preserved parts may be easily handled. This grade has proved particularly effective in protecting wheel well areas and other exposed surfaces where film transparency is required and moderate protective characteristics can be tolerated. The main disadvantages of this material is that it is easily removed by water spray and requires replacement at 1-month intervals under severe exposure conditions.

Corrosion-Preventive Petroleum

These preservatives are designed for hot application and are available in two classes—Class 1 (hard film) and Class 3 (soft film). Both consist of corrosion inhibitors in petroleum. They are removed with Stoddard Solvent or mineral spirits. Where a hard film is not necessary, Class 3 should always be used as it is easier to apply and remove yet renders the same degree of protection. Class 1 is generally used for long-time indoor protection of highly finished metal surfaces and aircraft control cables. Class 3 is used to provide protection of metal surfaces such as antifriction bearings, shock-strut pistons, and other bright metal surfaces.

Class 1 must be heated to 170° to 200° F before applying by brush or dip. For brushing class 3 material, it must be between 60° and 120° F and for dipping, between 150° and 180° F.

Oil, Preservative, Hydraulic Equipment

This oil is used in the preservation of hydraulic systems and components and shock struts. This oil is similar in appearance to, but is not interchangeable with, operating hydraulic fluid, therefore before using operating hydraulic fluid (MIL-H-5606) or this preservative oil (MIL-H-6083) for any purpose the specification number should be checked to ascertain that the correct oil is being used. The preservative oil contains oxidation and rust inhibitors, viscosity improver, and antiwear agents. Hydraulic parts and components being turned in for screening and repair are flushed and drip drained with MIL-H-6083 oil prior to being forwarded.

Designed primarily for hydraulic components this oil may be used on any bare critical surface that needs protection. Operating hydraulic fluid will protect a steel panel immersed in water for only about 48 hours. The same metal panel coated with MIL-H-6083 inhibited hydraulic oil will show 100-percent protection for a period of 30 days or more.

Lubrication Oil, General Purpose, Preservative

There are several different types of lubricating oil, some of which contain preservatives. In order to be absolutely sure that the proper oil is used in a given situation, each must be identified with its specification number. The specification number for the oil discussed in this section is VV-L-800 (supersedes MIL-L-644).

VV-L-800 oil was compounded for lubrication and protection of piano-wire hinges and other critical surfaces and whenever a water-displacing, low-temperature, lubricating oil is required.

VV-L-800 may be applied, as received, by brush, spray, or dip methods. It is readily removed with Stoddard solvent or mineral spirits.

Lubricating Oil, General Purpose, Low Temperature

This general purpose oil (Specification MIL-L-7870) is suitable for use anywhere that a general purpose lubricating oil with low temperature, low viscosity, and corrosive-preventive properties is required.

This oil is suitable for brush, spray, dip, or general squirt-can application. It is not necessary to remove before reoiling or for inspection.

Corrosion Preventive Compound (MIL-C-81309)

This material is a water displacing corrosion prevention compound and lubricant. It forms a thin, clear protective coating when applied by aerosol, brush, dip, or spray. It offers only short erm protection so must be reapplied frequently. On exposed surfaces, protection at its best would be 7 days between applications and up to 30 days on internal surfaces which are protected from direct outside environments. It is easily removed with drycleaning solvents. It is very effective when used in the following areas: Piano-wire hinges, removable fasteners, B-nuts, linkages, bolts and nuts, ejection seat mechanisms, canopy locks, control surface hinges, electrical connectors, and microswitches.

Packaging and Barrier Materials

A minimum of packaging is necessary at the operating activity level. However, critical aircraft and engine areas require shrouding against contamination during maintenance and repair. Fuselage openings require adequate seals when cleaning and stripping materials are used. At least three acceptable barrier materials are available in Navy stock for sealing and shrouding large aircraft openings.

WATER-VAPORPROOF BARRIER MATERIAL.—This material is a laminated metal foil barrier that has good water-vapor resistance and can be used for closing of intake openings, for protection of acrylics during cleaning, and for necessary packaging of removed components and accessories being returned to overhaul. It is heat sealable with a soldering or clothes iron.

POLYETHYLENE PLASTIC FILM.—This barrier material is used for the same purposes as the metal foil barrier material and is much less expensive. It is however not puncture resistant. The plastic film is heat sealable only with special equipment.

POLYETHYLENE COATING CLOTH.—This cloth is used to a great extent in ground support equipment covers. Its use is preferred over the plastic film material for general aircraft shrouding because of its greater tear and puncture resistance.

TAPE, FEDERAL SPECIFICATION PPP-T-60, TYPE 1, CLASS 1.—This pressure-sensitive tape is used for closure of small aircraft openings and for direct contact use on noncritical metallic surfaces. The tape has moderate water-vapor resistance, which is generally adequate for maintenance use. The main disadvantage of this tape is that some cloth-backed materials have not been preshrunk, and tape closures tend to pull loose when exposed to high humidity conditions.

PRESSURE SENSITIVE ADHESIVE TAPE.—This item is a material developed specifically for exterior preservation and sealing used in aircraft maintenance programs. It is designed for application at temperatures as low as 0° F and should perform satisfactorily over the temperature range from -65° F to 140° F. It is an excellent general purpose tape for exterior preservation and sealing operations.

CORROSION DETECTION

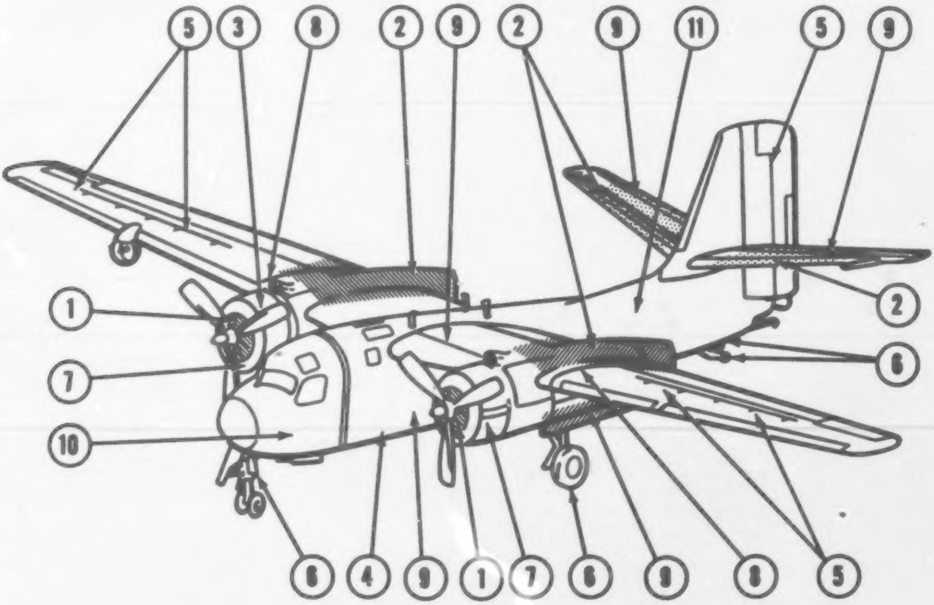
Timely detection of corrosion is essential to any corrosion control program. Of course corrosion can be detected after a part fails (if the aircraft can be recovered), but it is too late to do anything about if other than to intensify inspections of other, similar aircraft. Inspection for corrosion and deterioration should be a part of all routine inspections. There are, on every aircraft, certain areas that are more prone to corrosion than others. One should check these areas carefully. In order for the corrosion inspection to be thorough the person inspecting must know the types of corrosion likely to be found and the symptoms or appearance of each type. Sometimes corrosion is hidden and special detection methods are utilized in the search. Various aspects of corrosion detection are discussed in the following sections.

LOCATION OF CORROSION PRONE AREAS

Discussion of corrosion prone areas in this section includes trouble spots or areas that are common to all aircraft. For this reason, coverage for any given aircraft model is not necessarily complete. Figure 4-6 illustrates trouble spots applicable to a reciprocating engine aircraft. Reference to the Periodic Maintenance Requirements Cards for specific model aircraft will enable inspections to be amplified and expanded to the necessary degree.

Exhaust Trail Areas

Both jet and reciprocating engine exhaust deposits are very corrosive. These deposits are particularly troublesome where gaps, seams, hinges, and fairings are located down the exhaust path and where the deposits may be trapped and not reached by normal cleaning methods. Inspection of these surfaces should include special attention to the areas indicated in figure 4-7.



1. Engine frontal area.
2. Exhaust trail areas.
3. Battery compartment and vents.
4. Bilge areas.
5. Spot welded skin areas.
6. Landing gear and wheels. AM.53
7. Oil cooler passages.
8. Wing fold areas.
9. Hinges, piano wire type.
10. Relief tube vents.
11. Control cables.

Figure 4-6.—Typical corrosion prone areas on reciprocating engine aircraft.

Inspection procedures should also include the removal of fairings and access panels located in the exhaust path.

JATO, Rocket, and Gun Blast Areas

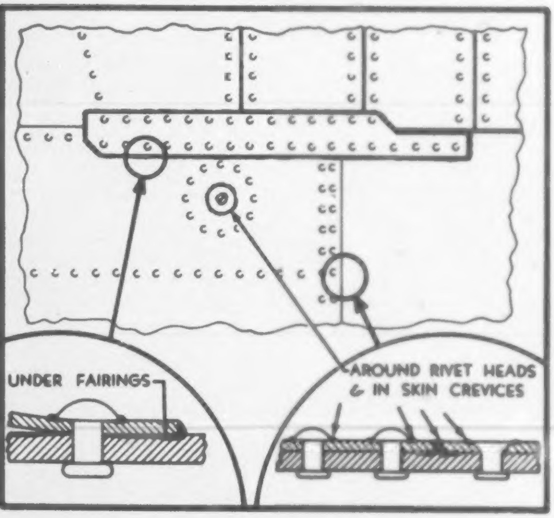
Surfaces located in the path of JATO, rocket, and gun blasts are particularly subject to corrosive attack and deterioration (fig. 4-8). In addition to the corrosive effect of the gases and exhaust deposits, protective finishes are often blistered by heat, blasted away by high-velocity gases, or abraded by spent shell casings or solid particles from gun and rocket exhausts. These areas should be watched for corrosion and cleaned carefully after firing operations.

Battery Compartments and Battery Vent Openings

Fumes from battery electrolyte are difficult to contain and will spread throughout the battery compartment, vents, and even adjacent internal cavities, causing rapid, corrosive attack on unprotected surfaces. The external skin area around the vent openings should also be checked regularly for the type corrosion. Corrosion from this cause will continue to be a serious problem whenever batteries are used.

Lavatories and Galleys

These areas, particularly on the deck behind lavatories, sinks, and ranges, where spilled food and waste products may accumulate, are



AM. 54
Figure 4-7.—Exhaust trail corrosion points.

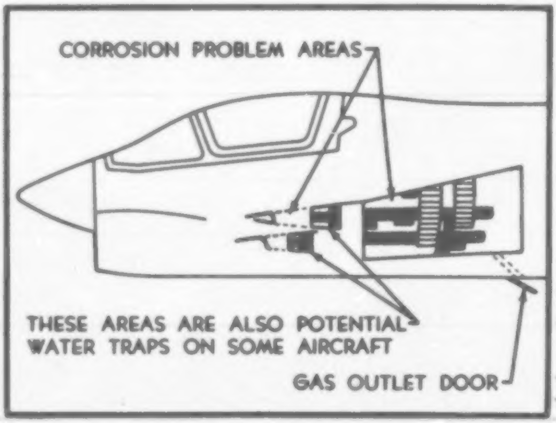
likely trouble spots if not kept clean. Even if some contaminants are not corrosive in themselves, they may attract and hold moisture, which in turn causes corrosive attack. Inspectors should pay attention to bilge areas located under galleys and lavatories, and to personnel relief and waste disposal vents or openings on the aircraft exteriors. Human waste products are very corrosive to the common aircraft metals.

Bilge Areas

A common trouble spot on all aircraft is the bilge area. This is a natural collection point for waste hydraulic fluids, water, dirt, loose fasteners, drill shavings, and other odds and ends of debris. Oil puddles quite often mask small quantities of water which settle to the bottom and set up hidden corrosion cells. Keeping bilge areas free of all extraneous materials, including oil, is the best insurance against corrosion.

Wheel Wells and Landing Gear

The wheel well area probably receives more punishment than any other area on the aircraft. It is exposed to mud, water, salt, gravel, and other flying debris from runways during flight operations and is open to salt water and salt spray when the aircraft is parked aboard ship. Due to the many complicated shapes, assemblies, and fittings in the area, complete coverage with a protective paint film is difficult to attain. Because of the heat generated from braking, preservative coatings cannot be used on jet aircraft landing gear wheels. During inspections, particular attention should be given the following:



AM. 55
Figure 4-8.—Gun blast area corrosion points.

Magnesium wheels, especially around boltheads, lugs, and wheel web areas.

Exposed metal tubing, especially at nuts and ferrules, and under clamps and identification tapes.

Exposed position-indicator switches and other electrical equipment.

Crevices between stiffeners, ribs, and lower skin surfaces which are typical water and debris traps.

Water Entrapment Areas

Design specifications require that aircraft have drains installed in all areas where water may collect. However, in many cases these drains may not be effective, either due to improper location or because they are plugged by sealants, extraneous fasteners, dirt, grease, and debris. Daily inspection of drains should be a standard requirement, especially aboard ship.

Wing Fold, Flap, and Speed Brake Recesses

Flap and speed brake recesses are potential corrosion problem areas mainly because they are normally closed when on the ground. Dirt and water may collect and go unnoticed. Wing fold areas present a different problem and, like wheel wells, contain many complicated shapes and assemblies which are difficult to cover with a protective paint coating or preservative film. Wing fold areas are extremely vulnerable to salt spray when wings are folded aboard ship. Thorough inspection of this area should include a mirror check of the back sides of tubing and fittings. Also, particular attention should be paid to aluminum alloy wing lock fittings such as are used on some current aircraft models.

External Skin Areas

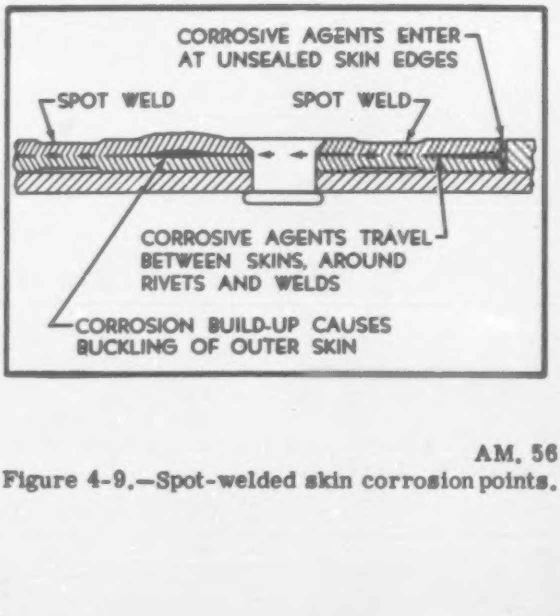
Most external aircraft surfaces are ordinarily covered with protective paint coatings and are readily visible or available for inspection and maintenance. Even here, certain types of configuration or combinations of materials become troublesome under shipboard operating conditions and require special attention if serious corrosion difficulties are to be avoided.

Magnesium skin, when painted over, is not visibly different from any other painted metal surface. However, those surfaces which are of magnesium are identified in the applicable Structural Repair Manual. When aircraft contain magnesium skin panels, these must be given special attention during inspections for corrosion. Some current aircraft have steel fasteners installed through magnesium skin with only protective finishes under the fastener heads or tapes over the surface for insulation. In addition, all paint coatings are thin at trimmed edges and corners. These conditions, coupled with magnesium's sensitivity to salt water attack, make up a potential corrosion problem whenever magnesium is used. Therefore, any inspection for corrosion should include the location and inspection of all magnesium skin surfaces, with special attention to edges, areas around fasteners, and cracked, chipped, or missing paint.

Corrosion of spot-welded skins is chiefly the result of the entrance and entrapment of corrosive agents between the layers of metal. (See fig. 4-9.) Some of the corrosion may be caused originally by fabricating processes, but its progress to the point of skin bulging and spot-weld fracture is the direct result of moisture or salt water working its way in through open gaps and seams. This type of corrosion is first evidenced by corrosion products appearing at the crevices through which the corrosive agents entered. Corrosion may appear at other external or internal faying (closely joined) surfaces, but is usually more prevalent on external areas. More advanced corrosive attack causes skin buckling and eventual spot-weld fracture. Skin buckling in its early stages may be detected by sighting along spot-welded seams or by using a streightedge.

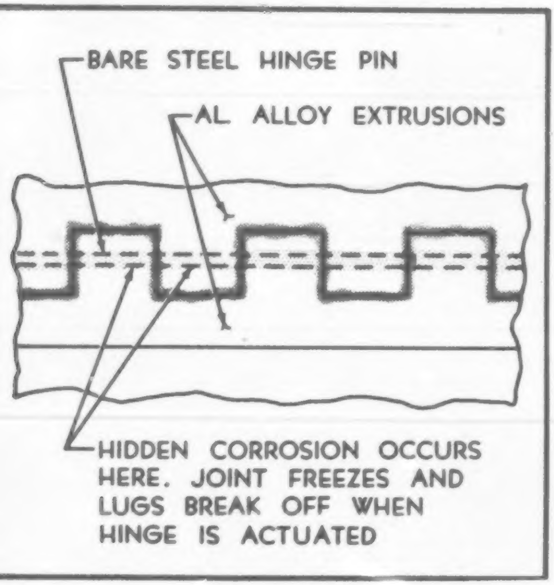
Piano Type Hinges

Figure 4-10 illustrates the effect of corrosion on the piano-wire type hinges used on most aircraft. These are not only prime spots for corrosion due to the dissimilar metal contact between the steel pin and aluminum hinge tangs, but are also natural traps for dirt, salt, and moisture. When this type of hinge is used on access doors and plates which are opened only during periodic inspections, they tend to freeze in place between inspections. The inspection for corrosion of these hinges should include lubrication and actuation through several cycles to insure complete penetration of the lubricant.


CORROSIVE AGENTS ENTER AT UNSEALED SKIN EDGES
SPOT WELD
SPOT WELD
CORROSIVE AGENTS TRAVEL BETWEEN SKINS, AROUND RIVETS AND WELDS
CORROSION BUILD-UP CAUSES BUCKLING OF OUTER SKIN

AM. 56

Figure 4-9.—Spot-welded skin corrosion points.


BARE STEEL HINGE PIN
AL ALLOY EXTRUSIONS
HIDDEN CORROSION OCCURS HERE. JOINT FREEZES AND LUGS BREAK OFF WHEN HINGE IS ACTUATED

AM. 57
Figure 4-10.—Hinge corrosion points.

Ejection Seats

Aboard ship, salt spray is admitted into most cockpit areas when the canopies are opened for respotting of aircraft, maintenance, or to accommodate the manning of ready alert aircraft, etc. While the cockpit and ejection seats are not considered as corrosion prone as some other areas, they are subjected to a corrosive environment and require constant attention along with other parts of the aircraft. The construction, location, and difficulty encountered in thoroughly inspecting and cleaning the ejection seat while it is installed in the aircraft, along with the lengthy time between aircraft inspections that require seat removal, could result in the ejection seat becoming severely corroded if not given adequate attention. The possibility that slight corrosion could render the seat inoperable must not be overlooked. The Maintenance Requirements Cards for the ejection seats require that every portion of the seat be checked thoroughly for corrosion when it is removed from the aircraft during calendar/periodic inspections. Additional emphasis is usually given to the ultra-high-strength steel parts of the seat. Worn paint finishes and those showing signs of superficial corrosion should be given immediate attention in accordance with the applicable Maintenance Instructions Manual. Cockpit fasteners should be replaced whenever there is evidence of corrosion. Bright metal fasteners should be touched up with dull black paint to prevent cockpit glare.

APPEARANCE OF CORRODED PARTS

One of the problems involved in corrosion control is recognizing corrosion products when they occur. The following paragraphs include brief descriptions of typical corrosion product characteristics of the more common materials of aircraft construction. Photographs of typical corroded surfaces are provided in NavAir 01-1A-509 and reference to that publication will enable maintenance personnel to become more familiar with and be able to identify corrosion in its various stages.

Iron and Steel

Possibly the best known and easiest recognized of all forms of metals corrosion is the familiar reddish colored iron rust. When iron and its alloys corrode, dark iron oxide coatings usually form first, and these coatings, such as heat scale on steel sheet stock, may protect iron surfaces rather efficiently. However, if sufficient oxygen and moisture are present, the iron oxide is soon converted to hydrated ferric oxide, which is the conventional red rust.

Aluminum

Aluminum and its alloys exhibit a wide range of corrosive attack, varying from general etching of the surfaces to penetrating attacks along the internal grain boundaries of the metal. The corrosion products are seen as white to gray powdery deposits and more voluminous than the original metal. In its early stages, aluminum corrosion is evident as general etching, pitting, and roughness of the surface. The surface attack progresses quite slowly at first; however, it will be accelerated if corroding material is not given immediate attention.

Paint coatings tend to mask evidence of corrosion, but the fact that the corrosion products are more voluminous will result in corrosion showing up as blisters, flakes, chips, lumps, or other irregularities in the paint coating. Often white or gray streaks of corrosion products will become readily apparent at breaks in the paint film. Any such indications should result in further investigation to determine the extent that corrosion has progressed.

Magnesium and Its Alloys

Magnesium corrosion products are white and quite large compared to the size of the base metal being corroded. The deposits have a tendency to raise slightly and the corrosion spreads rapidly. When white puffy areas are discovered on magnesium it requires prompt attention as the corrosion may penetrate entirely through the structure in a very short time.

Copper and Copper Alloys

Copper and its alloys are generally corrosion resistant, although the products of corrosive attack on copper are commonly known. Sometimes copper or copper alloy surfaces will tarnish to a dull gray-green color and the surface may still be relatively smooth. This discoloration is the result of the formation of a fine-trained, airtight copper oxide crust, called a patina. This patina in itself offers good protection for the underlying metal in ordinary situations. However, exposure of copper and copper alloys to moisture or salt spray will cause the formation of blue or green salts indicating active corrosion. These salts will form over the patina since this crust is not impervious to water (not moistureproof). Copper alloys used in aircraft generally have a cadmium-plated finish to prevent surface staining and deterioration.

Cadmium and Zinc

Cadmium, particularly, is used as a coating to protect the part to which it is applied and to provide a compatible surface when the part is in contact with other materials. The cadmium plate supplies sacrificial protection to the underlying metal because of its greater activity. That is, during the time it is protecting the base metal, the cadmium is intentionally being consumed. It functions in the same way that an active magnesium rod inserted in the water system protects the piping of a hot water heater. The cadmium becomes anodic and is attacked first, leaving the base metal free of corrosion. Zinc coatings are used for the same purpose, but to a lesser extent in aircraft. Attack is evident by white to brown to black mottling of the cadmium surfaces. These indications DO NOT indicate deterioration of the base metal. Until the characteristic colors peculiar to corrosion of the base metal appear, the cadmium is still performing its protective function. Wire brushing or removal of the mottled areas of cadmium merely reduces the amount of cadmium remaining to protect the underlying structure.

Nickel and Chromium Alloys

These metals are also used as protective agents, both in the form of electroplated coatings and as alloying constituents with iron in stainless steels. Nickel and chromium plate protect by forming an actual physical noncorrosive barrier over the steel. Electoplated coatings, particularly chromium on steel, are somewhat porous, and corrosion eventually starts at these pores or pin holes unless a supplementary coating is applied and maintained.

Titanium

Titanium is becoming more commonly used in aircraft construction. It is a highly corrosion-resistant metal, but it may show some surface deterioration from the presence of salt deposits and other impurities, particularly at higher temperatures. Corrosion products appear as minute surface cracks. When used with other metals, insulation must be used to prevent dissimilar metal attack on the other metals.

FORMS OF CORROSION

Corrosion may occur in several forms, depending upon the metal involved, its size and shape, its specific function, atmospheric conditions, and the corrosion-producing agents present. Those described in this section are the more common forms found on aircraft structures. Corrosion has been cataloged and typed in many ways. For descriptive purposes, the types are discussed here under what is considered the most commonly accepted titles.

Direct Surface Attack

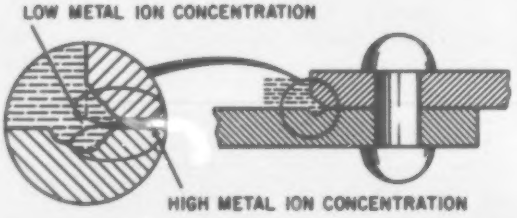
The surface effect produced by the direct reaction of the metal surface with oxygen in the air is a uniform etching of the metal. The rusting of iron and steel, the tarnishing of silver, and the general dulling of aluminum surfaces are common examples of surface attack. On aluminum surfaces if such surface attack is allowed to continue unabated, the surface will become rough and eventually frosted in appearance.

Pitting Corrosion

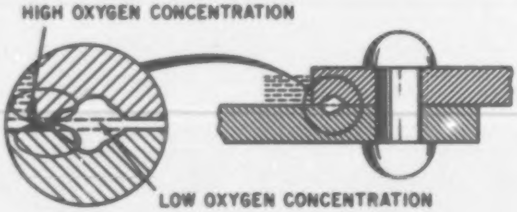
The most common effect of corrosion on aluminum and magnesium alloys is called pitting. It is due primarily to the variation in structure or quality between areas on the metal surface in contact with a corrosive environment. Pitting corrosion is first noticeable as a white or gray powdery deposit, similar to dust, which blotches the surface. When the superficial deposit is cleaned away, tiny pits or holes can be seen in the surface. They may appear as relatively shallow indentations or deep cavities of small diameter. Pitting may occur in any metal, but it is particularly characteristic of aluminum and magnesium.

Crevice Attack or Concentration Cell

Concentration cell corrosion is actually a form of pitting corrosion which is caused by the difference in concentration of the electrolyte or the active metal at the anode and cathode. When there is concentration differences at two different points in an entrapped pool of water or cleaning solution, anodic and cathodic areas may result, and the anodic area will be attacked. Figure 4-11 illustrates the theory of concentration cell corrosion. This type of attack is generally detected where there are crevices, scale, surface deposits, and/or stagnant water traps. This type corrosion is controlled and prevented by keeping areas cleaned, by eliminating the possibility of water accumulation, by avoiding the creation of crevices during repair work, and by elimination of any existing voids which may become water traps by the use of approved sealants and caulking compounds.



METAL ION CONCENTRATION CELL RIVETED LAP JOINT



OXYGEN CONCENTRATION CELL

AM. 1128

Figure 4-11.—Concentration cell corrosion.

Intergranular Attack Including Exfoliation

Intergranular corrosion is an attack on the grain boundaries of some alloys under specific conditions. During heat treatment, these alloys are heated to a temperature which dissolves the alloying elements. As the metal cools, these elements combine to form compounds; and if the cooling rate is slow, they form discriminantly at the grain boundaries. These compounds differ electrochemically from the material adjacent to the grain boundaries and can be either anodic or cathodic to the adjoining areas, depending on their composition. The presence of an electrolyte will result in attack of the anodic area. This attack will generally be quite rapid and can exist without visible evidence.

As intergranular corrosion progress to the more advanced stages, it reveals itself by lifting up the surface grain of the metal by the force of expanding corrosion products occurring at the grain boundaries just below the surface. This advanced attack is referred to as EXFOLIATION, and its recognition by corrosion personnel and immediate action to correct such serious corrosion is vital to aircraft safety. The insidious nature of such an attack can seriously weaken structural members before the volume of corrosion products accumulate on the surface and the damage becomes apparent.

Metal that has been properly heat-treated is not readily susceptible to intergranular attack;

however, susceptibility can develop from localized overheating, such as could occur from welding, fire damage, etc. If the intergranular attack has not penetrated too far and sufficient structural strength remains, corrective procedures as outlined in the applicable Structural Repair Manual could restore the aircraft to a flight status.

Whenever intergranular corrosion is evident or suspected, it should be immediately brought to the attention of senior personnel who can initiate appropriate action.

Dissimilar Metal Corrosion

Galvanic or dissimilar metal corrosion is the term applied to the accelerated corrosion of metal caused by dissimilar metal being in contact in a corrosive medium such as salt spray or water.

Dissimilar metal corrosion is usually a result of faulty design or improper maintenance practices which result in dissimilar metals coming in contact. It is usually recognizable by the presence of a build-up of corrosion at the joint between the metals. For example, aluminum and magnesium materials riveted together in an aircraft wing form a galvanic couple if moisture or contamination is present. When aluminum pieces are attached with steel bolts or screws, galvanic corrosion can occur around the fasteners.

Aircraft manufacturer's utilize a variety of separating materials such as plastic tape, sealant, primer, washers, lubricants, etc., to keep these metals from coming in direct contact and thus keep corrosion to a minimum. It is imperative that these separating materials remain intact or are replaced, restored, or repaired as necessary throughout the life of the aircraft.

Since some metals are more active than others, the degree of attack will depend on the relative activity of the two surfaces in contact. In any case, the more active or easily oxidized surface becomes the anode and corrodes. In plated metal the possibility of dissimilar metal corrosion becomes a factor only if there are defects in the plating, which would allow moisture penetration and subsequently the forming of a galvanic cell.

Stress Corrosion

Stress corrosion, evidenced by cracking, is caused by the simultaneous effects of tensile stress and corrosion. Stress may be internal or applied. Internal stresses are produced by nonuniform deformation during cold working, by unequal cooling from high temperatues during heat treatment, and by internal structural rearrangement involving volume changes. Stresses set up when a piece is deformed, those induced by press and shrink fits, and those in rivets and bolts are examples of internal stresses. Concealed stress is more important than design stress, especially because stress corrosion is difficult to recognize before it has overcome the design safety factor. The magnitude of the stress varies from point to point within the metal. Stresses in the neighborhood of the yield strength are generally necessary to promote stress corrosion cracking, but failures have occurred at lower stresses.

Fatigue Corrosion

Fatigue corrosion is a special kind of stress corrosion and is caused by the combined effects of corrosion and stresses applied in cycles to a part. (NOTE: An example of cyclic stress is the alternating loads to which the reciprocating rod on the piston of a hydraulic, double-acting actuating cylinder is subject. During the extension stroke a compression load is applied and during the retracting or pulling stroke, a tensile or stretching load is applied.) Damage from fatigue corrosion is greater than the combined damage of corrosion and cyclic stresses if the part was exposed to each separately. Fracture of a metal part due to fatigue corrosion generally occurs at a stress far below the fatigue limit in a laboratory environment, even though the amount of corrosion is unbelievably small. For this reason, protection of all parts subject to alternating stress is particularly important wherever practical, even in environments that are only mildly corrosive.

Fretting Corrosion

Fretting corrosion is a limited by highly damaging type of corrosion caused by a slight vibration, friction, or slippage between two contacting surfaces which are under stress and heavily loaded. It is usually associated with machined parts, such as the area of contact of bearing surfaces, two mating surfaces, and bolted or rivited assemblies. At least one of the surfaces must be metal. In fretting corrosion, the slipping movement at the interface of the contacting surface destroys the continuity of the protective films that may be present on the metallic surface. This action removes fine particles of the basic metal. The particles oxidize and form abrasive materials which further agitate within a confined area to produce deep pits. Such pits are usually so located as to increase the fatigue failure potential of the metal. Fretting corrosion is evidenced at an early stage by surface discoloration and by the presence of corrosion products in any lubrication present. Lubrication and securing the parts so that they are rigid are the most effective measures to prevent this type of corrosion.

Filiform Corrosion

Filiform corrosion is threadlike filaments of corrosion known as underfilm. Metals coated with organic substances, such as paint films, may undergo this type of corrosion.

Filiform corrosion occurs independent of light, metallurgical factors in the steel, and bacteria but takes place only in relatively high humidity, 65 to 95 percent. Although the threadlike filaments are visible only under clear lacquers or varnishes, they also occur with some frequency under opaque paint films. Filiform corrosion can occur on steel, zinc, aluminum, magnesium, and chromium plated nickel.

Microbiological Corrosion

Micro-organisms contained in sea water can be introduced into fuel systems by contaminated fuel. These fungus growths attack the sealing material used on integral fuel tanks. Under certain conditions, they can cause corrosion of aluminum probably by aiding in the formation of concentration cells. Residues resulting from biological growth tend to clog fuel filters, and coat fuel capacity probes, giving erroneous fuel quantity readings.

SPECIAL DETECTION METHODS

A variety of nondestructive inspection methods may be utilized by the structural mechanic in detecting flaws in metal. Special methods to detect intergranular corrosion using ultrasonics and eddy current principles familiar to some specially trained senior structural mechanics have been developed. Knowledge of these more sophisticated methods is not required at the AME 3&2 petty officer level. Any time there is even the slightest concern over the extent of intergranular corrosion damage or suspected damage, these specially developed methods should be conducted by qualified personnel.

AME 3 & 2 personnel are required to have knowledge concerning the variety of penetrant inspections used to detect various types of discontinuities which are open to the surface of the material. Penetrant inspections provide a quick and reliable means of detecting such flaws and are suitable for detecting the depth of intergranular cracks or other general defects.

The various types and methods of inspections are suitable for locating almost any type of defect open to the surface on a variety of nonabsorbent materials such as, ferrous and nonferrous metals, ceramics, hard rubber, plastic, and glass.

The following section will provide basic coverage on the types and methods of penetrant inspection, general inspection procedures, and interpretation of results. Complete and detailed coverage necessary for a thorough understanding of the penetrant methods of inspection is provided in NavAir 01-1A-16, Nondestructive Inspection Methods, Technical Manual. Tests on critical aircraft components require a thorough knowledge of all material included in that section of the manual for the specific test being conducted to insure proper testing and interpretation.

PENETRANT INSPECTIONS

Penetrant inspection is a nondestructive test for defects open to the surface in parts made of any nonporous material. Penetrant inspection depends for its success upon a penetrating liquid entering the surface opening and remaining in that opening, making it clearly visible for the operator. It calls for visual examination of the part by the operator after it has been processed, but the visibility of the defect is increased so that it can be detected. Visibility of the penetrating material is increased by the addition of dye which may be either one of two types–visible or fluorescent.

The main disadvantage of penetrant inspection is that the defect must be open to the surface in order to let the penetrant into the defect. For this reason, if the part in question is made of material which is magnetic, the magnetic particle inspection or X-ray is generally recommended. It is also essential that there be no contaminant within the defect which might either prevent the penetrant from entering or which may reduce its visibility.

The materials used in the visible dye penetrant inspection are available in aviation supply stock in the form of a complete inspection kit. Included in the kit are the following items: two spray cans of penetrant, dye remover-emulsifier, and developer. For replenishment purposes, these materials are also available as individual items. The chemicals are available in ordinary containers for use when dipping or brushing is desired.

The fluorescent inspection materials and equipment are also furnished in kit form. The complete equipment is contained in a metallic carrying case. Included are the following items: penetrant, penetrant cleaner, penetrant developer (both powder and suspension types), dauber for applying powder, and a black light (ultraviolet) assembly complete with power transformer. The chemicals may be replenished individually from aviation supply stock.

General Inspection Procedure

First of all, the part to be inspected must be clean. This includes the removal of surface dirt, scale, paint, and oil, as well as removing any materials or compounds that might fill or cover the defects. If the part has been in contact with water it may be possible to heat the part slightly to evaporate the water.

Penetrant is then applied to all surfaces. This may be done by dipping, flow-on, brushing, or spraying. It is important that all suspect areas be wet with penetrant. The penetrant must be allowed to remain on the part for a period of time called the penetration (dwell) time. This allows the penetrant to seek and fill surface openings. The length of the penetration time varies with the process and techniques used, the material of which the part is made, and the types of defects present.

The excess surface penetrant is removed from the part by means of a forceful water spray. This operation does not remove the penetrant from deep defects but does remove the penetrant on the surface.

A developer is then applied to the part before inspection. The function of the developer is to blot back to the surface the penetrant that is entrapped in fissures or defects in the part. The developer should be allowed to remain on the part for a time before inspection for defects. This elapsed time is to allow the developer to bring back to the surface and magnify the traces of penetrant. Some types of defects in some parts may be detectable without the use of a developer, but for consistent and positive results, current instructions recommend that a developer always be used. A drying operation is necessary which increases the effectiveness of the method and, depending upon the type of developer used, either dries the wet developer or prepares the part for the application of the dry developer.

After the proper developing time has elapsed, the part is ready for inspection. If the penetrant used has a fluorescent dye in it, the inspection must be performed in a darkened area and under black light. If the penetrant used has visible dye, then inspection can be performed under ordinary lighting conditions.

All traces of the developer should be removed from the part before it is returned to service.

Types of Processes

There are two types of penetrant inspection processes. Type I employs the use of fluorescent penetrants, and Type II processes employ the use of visible dye penetrants. Within each type there are three methods, which are referred to as methods A, B, and C. Each method within a type uses a specific group of materials. Table 4-1 lists the types and methods of penetrant inspection and their related group of materials.

Group I through group III penetrants are visible dye penetrants containing dyes that make them readily visible when exposed to natural or artificial white light. Penetrants in group I are removed by wiping with a cloth dampened by a specially prepared compatible solvent supplied with the portable penetrant kit. Penetrants in group II are water washable (for removal) after application of an emulsifier. This two-step process makes group II penetrants more suitable for detecting wide, shallow defects. Group II penetrants are referred to as post-emulsifiable penetrants. Group III penetrants contain an emulsifier which makes them water washable as furnished.

Group IV through VII penetrants contain dyes which will fluoresce (glow) when exposed to black light. Group IV penetrants contain an emulsifier which makes it water washable as furnished. Groups V and VI are water washable after application of an emulsifier the same as group II. Group VII penetrants are removed by wiping with a solvent-dampened cloth the same as group I.

Table 4-1. —Penetrant inspection types, methods, and material groups.

Type	Method	Penetrant Used	MIL-I-25135 Material Group Used	Family of Items in Group
I	A	Water-washable fluorescent dye.	Group IV	Consists of a water-washable fluorescent penetrant and a dry, wet, or nonaqueous wet developer.
I	B	Post-emulsifiable fluorescent dye.	Group V	Consists of a post-emulsifiable fluorescent penetrant, an emulsifier, and a dry, wet or nonaqueous wet developer.
			Group VI	Consists of a high-sensitivity post emulsifiable fluorescent penetrant, an emulsifier, and a dry, wet, or nonaqueous wet developer.
I	C	Solvent-removable fluorescent dye.	Group VII	Consists of a solvent-removable fluorescent penetrant, a penetrant remover (solvent) and a nonaqueous wet developer.
II	A	Water-washable visible dye.	Group III	Consists of a water-washable visible dye penetrant and a dry, wet, or nonaqueous wet developer.
II	B	Post-emulsified visible dye.	Group II	Consists of a post-emulsifiable visible dye penetrant, an emulsifier, and a dry, wet, or nonaqueous wet developer.
II	C	Solvent-removable Visible dye	Group I	Consists of a solvent-removable visible dye penetrant, a penetrant remover (solvent), and a dry, wet, or nonaqueous wet developer.

Selection of Inspection Process

The selection of the best type of penetrant inspection suitable for the job at hand will depend on several factors as follows:

1. Previously established requirements specified on documents requiring the inspection.
2. Penetrant sensitivity required.
3. Surface condition of the part.
4. Configuration of the part.
5. Number of parts to be tested.
6. Facilities and equipment available.
7. Effect of the penetrant chemicals on the material being tested.

TYPE I, METHOD A, INSPECTION PROCESS.—This method lends itself to inspecting large volumes of parts, large areas, rough surfaces, and threads and keyways. It is the recommended type/method to be used when:

Discontinuities are not wider than their depth.

The lowest fluorescent penetrant sensitivity is sufficient to detect the defects inherent to the part.

Removal of excess penetrant may be difficult due to rough surfaces on the part.

Sulfonates in the emulsifying agents will not affect nickel bearing steels.

NOTE: This method is not recommended for detecting extremely fine intergranular corrosion or stress corrosion defects.

The water-washable fluorescent dye penetrant used in this type/method insures good visibility of flaw patterns and can be easily washed off with water. Since it is considered a one-step process, it is fast and economical in time and is relatively inexpensive to perform. This process is not reliable in finding scratches and shallow discontinuities as the penetrant is susceptible to overwashing. It is not reliable on anodized surfaces, and the penetrant can be affected by acids and chromates.

Following precleaning and drying, the water-washable fluorescent penetrant is applied to the surface being inspected by dipping, flow-on, spraying, or brushing methods. After the predetermined dwell time, it is flushed from the surface with a low-pressure (20-30 psi) spray of cold water. The developer is then applied and will cause the penetrant to bleed from any discontinuities or defects, and these flaw indications will become visible when exposed to black light.

TYPE I, METHOD B, INSPECTION PROCESS.—This method is used when inspecting large volumes of parts which may have defects that are contaminated with inservice soils or that may be contaminated with acids or other chemicals that will harm water-washable penetrants. It is the type/method recommended for use when:

A higher sensitivity than that offered by Type I, Method A, is required.

Discontinuities are wider than their depth.

Inspecting parts for stress cracks, intergranular corrosion, or grinding cracks.

Variable, controlled sensitivities are necessary so that nondetrimental discontinuities can be disregarded while harmful or detrimental ones can be detected.

The group V penetrant used with this type/method is more sensitive than the group IV penetrant of Type I, Method A; however, the group VI penetrant used with Type I, Method B, is more sensitive than group V.

NOTE: Only group VI materials are used for inspecting for stress cracks or intergranular corrosion.

The fluorescent penetrant used in this process is more brilliant than other processes and affords greater visibility when exposed to black light. For field use where light exclusion is not always possible, it provides the greatest degree of brilliance.

The Type I, Method B, process is highly sensitive to fine defects and is also good on wide, shallow defects. The penetrant washes easily after emulsification and the penetrant is not as susceptible to overwashing. Since it is considered a two-step process, because of the emulsifier, it is slower than Type I, Method A. The process is not as good on rough surfaces, keyways, or threads; and because of the extra materials used in the inspection, it is slightly more expensive.

Following precleaning and drying, the post-emulsifiable fluorescent penetrant is applied to the surface being inspected. After being allowed to dwell for the predetermined time, the emulsifier is applied. The emulsifier combines with the penetrant and is water washable. The excess penetrant is then removed using a low-pressure (30 to 40 psi) spray of cold water. The part is then thoroughly dried and the developer applied. The penetrant is then drawn to the surface and any flaw indications will become apparent as a brilliant greenish-yellow color when exposed to black light. The sensitivity of this process can be controlled by the type of penetrant used, dwell time, emulsifying time, rinsing technique, and drying temperature and time.

TYPE I, METHOD C INSPECTION PROCESS.—This method is used for spot inspection on large or small parts where the water rinsing method is not feasible because of part size, weight, surface conditions, and lack of water, or there is no heat for drying or field use. The use of solvent required to remove the penetrant prohibits this process in inspecting large areas. Its sensitivity can also be reduced by the application of excessive amounts of penetrant remover.

Following precleaning and drying, the solvent removable fluorescent penetrant is applied to the surface being inspected by dipping, flow-on, spraying, or brushing methods. After the predetermined dwell time, it is then removed with the solvent remover. The part is thoroughly dried and developer is applied. Penetrant will bleed from any discontinuities or defects and the flaw indications will be apparent when exposed to black light.

TYPE II, METHOD A, INSPECTION PROCESS.—This process is utilized for inspection surfaces when the circumstances described for Type I, Method A, exist and a fluorescent dye penetrant is not necessary. A black light is not needed; therefore, the work area need not be darkened. The process is relatively inexpensive, highly portable, excellent for spot checking, and can be used on anodized parts. The penetrant is easily washed off with fresh water.

Following precleaning and drying, the water-washable visible dye penetrant is applied by dipping, flow-on, spraying, or brushing methods. After the predetermined dwell time, it is flushed from the surface with a low-pressure spray of water and the surface is dried. The application of developer then draws out penetrant left in any discontinuities or defects, and these flaw indications should appear clearly against the white developer background. The indications can be easily seen in natural or artificial light.

TYPE II, METHOD B, INSPECTION PROCESS.—This method is used when a higher sensitivity than that afforded by Type II, Method A, is required. It is used when inspecting large volumes of parts, parts that are contaminated with acid or other chemicals that will harm water-washable penetrants, parts which may have defects that are contaminated with inservice soils, and for inspecting finished surfaces and other general purpose applications.

The materials in this process are the most sensitive of the visible dye penetrant inspection methods; however, it is not recommended for detecting extremely fine intergranular corrosion or stress corrosion defects.

Following precleaning and drying, the post-emulsifiable visible dye penetrant is applied to the surface being inspected by dipping, flow-on, spraying, or brushing methods. After this group II penetrant is allowed to dwell for a predetermined time, the emulsifier is applied. The emulsifier combines with the penetrant, which becomes water washable. The excess penetrant is then washed off using a low-pressure (30-40 psi) spray of cold water. Application of the desired developer will then draw out and absorb the intense red penetrant from the discontinuity to provide a clear indication against the white developer background.

TYPE II, METHOD C, INSPECTION PROCESS.—This method is used when spot inspection is required and where water rinsing is not feasible. The use of solvent in removing the penetrant prohibits inspection of large areas and the process is not adaptable for detecting extremely fine defects.

Following precleaning and drying, the solvent removable visible dye penetrant is applied as with previous methods. After the predetermined dwel time, it is removed from the surface with solvent remover and the part is thoroughly dried. The application of the developer draws out the bright red indication as with the other two visible penetrant types and methods.

EMULSIFIERS.—The emulsifiers discussed under the various types and methods are liquid additives which, when applied to post-emulsifiable penetrants, combine with the excess surface penetrant to render it water removable. These emulsifiers have low penetrating properties, a necessary feature to avoid having the emulsifier remove the penetrant from the discontinuity. They are of a contrasting color to the post-emulsifiable penetrant so that it can be determined easily if all the emulsifier has been removed during the water rinsing. Proper rinsing of fluorescent emulsifers is checked using the black light. Emulsifier dwell time is that time which it takes for the emulsifier to mix with the surface penetrant in order for it to rinse properly.

DEVELOPERS.—As previously mentioned under the types and methods (table 4-1), there are three types of developers—dry, aqueous wet, and nonaqueous wet.

Dry developer is a highly absorptive fluffy white powder. It is applied to the part after it has been thoroughly dried and provides a contrasting background to flaw indications and absorbs the penetrant at the defect. The dry type developers cause less bleeding of the penetrant indication and thus provide better resolution. The dry developer adheres primarily to the flaw openings wetted by the penetrant liquid and provides sharp flaw delineations. It is applied by dipping, dusting, or flow-on method.

Aqueous wet developer consists of an absorbent powder supplied in dry form which is mixed and suspended in water for application to the part being penetrant inspected. The suspension of the wet developer must be agitated to insure thorough suspension of the absorbent powder in the water. Excess penetrant is removed from the part and the wet developer is applied to the part while it is still wet. The wet developer, on drying, provides an absorbent white background for maximum color contrast and causes the penetrant to bleed from the flaw cavity, obtaining increased inspection accuracy. Wet developers cause greater bleeding and are more sensitive when applied as a spray. They are applied by dipping or flow-on method.

Nonaqueous wet developer consists of an absorbent powder suspended in a volatile liquid. This developer offers the highest relative sensitivity and is used primarily for spot inspection where the surface being inspected has not been heated during the process. The sensitivity of the developer can be increased by vibrating the spray gun during application. The preferred method of application is spraying. It may also be applied by brushing, but this is not generally preferred.

NOTE: Nonaqueous developers should not be applied to a hot part until the part has been cooled enough to be hand held. Some of the nonaqueous developers have a flash point of 50 ° F.

Developer dwell time will depend on the type of penetrant developer and the type of defect. Allow sufficient time for an indication to form, but do not allow penetrant to bleed into the developer in such quantities to cause a loss of defined indications.

The developer dwell time will vary from a few minutes to an hour or more. A good rule of thumb is as follows: development time for a given material or type of defect is about one-half of the time considered proper for penetration dwell time.

Interpreting Results

With penetrant inspections there are no false indications in the sense that such things occur in the magnetic particle inspection. However, there are two conditions which may create accumulations of penetrant that sometimes are confused with true surface cracks.

The first condition is a result of poor washing. If all the surface penetrant is not removed in the washing or rinse operation following the penetration time, the unremoved penetrant will be visible. This condition is usually easy to identify since the penetrant will be in broad areas rather than in the sharp patterns found with true indications. When accumulations of unwashed penetrant are found on a part, the part should be completely reprocessed. Degreasing is recommended for removal of all traces of the penetrant.

Another condition which may create false indications is where parts are press-fit to each other. For example, if a wheel is press-fit onto a shaft, the penetrant will show an indication at the fit line. This is perfectly normal since the two parts are not meant to be welded together. Indications of this type are easy to identify since they are so regular in form and shape.

The success and reliability of the penetration inspection depend upon the thoroughness with which the operator prepares the part from the precleaning all the way through to the actual search for indications. It is not a method by which a part is thrown into a machine which separates the good parts from the bad. The operator must carefully process the part, search out indications, and then decide the seriousness of defects found in order to determine the disposition of parts with indications. Penetrant inspections are important tools for finding defects before those defects grow into failures. As an operator, it is up to you to get the most out of the method used.

Fluorescent indications, when viewed under black light, fluoresce brilliantly and the extent of the indication marks the extent of the defect. Pores, shrinkage, lack of bond and leaks will show as glowing spots, while cracks, laps, forging bursts or cold shuts will show as fluorescent lines. Where a large defect has trapped a quantity of penetrant the indications will spread on the surface. Experience in the use of the method allows interpretations to be drawn from the extent of the spread as to the relative size of the defects. Grinding into certain defects, or sectioning and viewing under black light will rapidly build up experience and knowledge of the character of defects lying below various types of indications. For best results, inspection should be done in a darkened area. The darker the area of inspection, the more brilliant the indications will show. This is extremely important when looking for very fine indications. The inspection table should be kept free of random fluorescent materials. If penetrant has been spilled in the inspection area, on the table, or the operator's hands, it will fluoresce brilliantly and may confuse the operator.

Visible dye penetrant indications appear as red lines. As the developer dries to a smooth white coating, red indications will appear at the location of defects. If no red indications appear, there are no surface flaws present. No special lighting is required for the visible dye penetrant inspection.

It is possible to examine an indication of a discontinuity and to determine its cause as well

s its extent. Such an appraisal can be made if
omething is known about the manufacturing
rocesses to which the part has been subjected.
he extent of the indication, or accumulation of
enetrant, will show the extent of the discontinu-
y, and the brilliance will be a measure of its
epth. Deep cracks will hold more penetrant
nd therefore will be broader and more brilliant.
ery fine openings can hold only small amounts
f penetrant and therefore will appear as fine
nes.

The most effective training tool for identi-
ing and recognizing defects is a collection of
arts with typical defects which can be referred
frequently. Parts that have been rejected
ecause of defects should be clearly marked or
artially damaged so that they will not be con-
ised with acceptable parts. Unless the defects
re extremely large the indications will remain
n the parts for several months or longer.

It is not advisable to reinspect any part using
different type process than the one originally
sed. Fluorescent penetrants and visible dye
enetrants are not very compatible; therefore,
at all possible, if reinspection of a part is
equired, the original process should be
mployed.

Documentation of penetrant inspections can
e done on Support Action Forms (SAF's),
laintenance Action Forms (MAF's), or Techni-
al Directive Compliance Forms (TDCF's), de-
ending upon the circumstances which warrant
r require the inspection. Figure 4-12 illus-
rates the use of a MAF for penetrant inspection
uring a calendar inspection, and figure 4-13
'ustrates the TDCF being used because of an
ircraft Bulletin. When the MAF is used, the
orker in most cases initiates and completes
e form, while the TDCF is usually initiated
y Maintenance/Production Control, and the
orker complies with it and completes the form.

Detailed information on MAF's and TDCF's
nd their uses is covered in Military Require-
ents for Petty Officer 3 & 2, NavPers 10056-
, and OpNav 4790.2 (Series) Instruction.

CORROSION ELIMINATION

When corrosion of aircraft skin or structures
as been discovered, the first step to be taken
hould be the safe and complete removal of the
orrosion deposits or replacement of the af-
ected part. Which of these actions to be taken
epends upon the degree of corrosion, the extent
f damage, the capability to repair or replace, and the availability of replacement parts. Any part which has been damaged by corrosion should be replaced if continued use is likely to result in structural failure. Areas to be treated for corrosion deposit elimination must be clean, unpainted, and free of oil and grease. Chips, burrs, flakes of residue, and surface oxides must be removed. However, care must be taken to avoid removing, at the same time, too much of the uncorroded surface metal. Corrosion deposit removal must be complete. Failure to clean any surface debris permits the corrosion process to continue even after refinishing the affected areas.

When corrosion is present, any protective paint films must first be removed to insure that the entire corroded area is visble. After the corrosion has been removed the extent of damage must be assessed. It is at this point that the determination is made to repair or replace the affected part or to perform a corrosion correction treatment. This treatment involves the neutralization of any residual corrosion materials that may remain in pits and crevices, and the restoration of permanent protective coatings and paint finishes.

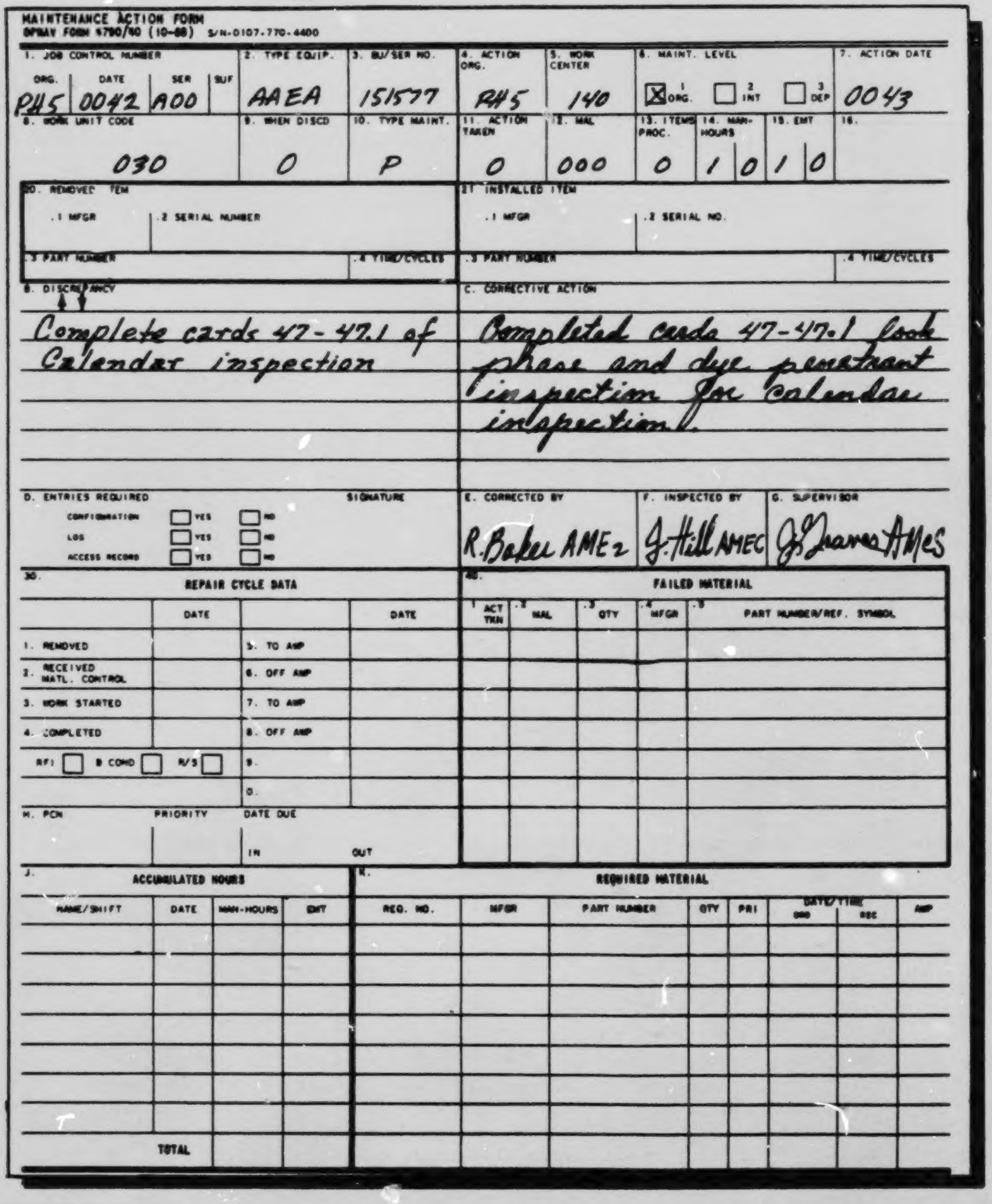
PAINT REMOVAL

Paint removal operations at the Organizational and Intermediate level of maintenance are usually confined to small areas, or possibly a whole panel. In all cases, the procedures outlined in the applicable Maintenance Instructions Manual should be observed. General stripping procedures are contained in Aircraft Cleaning and Corrosion Control for Organizational and Intermediate Maintenance Levels, NavAir 01-1A-509.

Materials

All paint removers are toxic and caustic; therefore, both personnel and material safety precautions must be observed in their use. Personnel should wear eye protection, gloves, and a rubber apron.

PAINT REMOVER, SPECIFICATION MIL-R-81294.—This is a new epoxy paint remover for use in the field. This remover will strip acrylic and epoxy finishes very satisfactorily. Acrylic windows, plastic surfaces, and rubber products are adversely affected by this material. This material should not be stocked in large quantities as it ages rapidly, degrading the results of stripping action.



MAINTENANCE ACTION FORM
OPNAV FORM 4790/60 (10-68) S/N-0107-770-4400

1. JOB CONTROL NUMBER ORG. PH5 | DATE 0042 | SER A00 | SUF	2. TYPE EQUIP. AAEA	3. BU/SER NO. 151577	4. ACTION ORG. PH5	5. WORK CENTER 140	6. MAINT. LEVEL ☒ 1 ORG. ☐ 2 INT ☐ 3 DEP			7. ACTION DATE 0043
8. WORK UNIT CODE 030	9. WHEN DISCD 0	10. TYPE MAINT. P	11. ACTION TAKEN 0	12. MAL 000	13. ITEMS PROC. 0	14. MAN-HOURS 1 | 0	15. EMT 1 | 0	16.

20. REMOVED ITEM .1 MFGR	.2 SERIAL NUMBER	21. INSTALLED ITEM .1 MFGR	.2 SERIAL NO.
.3 PART NUMBER	.4 TIME/CYCLES	.3 PART NUMBER	.4 TIME/CYCLES

B. DISCREPANCY	C. CORRECTIVE ACTION
Complete cards 47-47.1 of Calendar inspection	Completed cards 47-47.1 look phase and dye penetrant inspection for calendar inspection.

D. ENTRIES REQUIRED CONFIGURATION ☐ YES ☐ NO LOG ☐ YES ☐ NO ACCESS RECORD ☐ YES ☐ NO SIGNATURE	E. CORRECTED BY R. Baker AME2	F. INSPECTED BY J. Hill AMEC	G. SUPERVISOR J. Graves AMCS

30. REPAIR CYCLE DATA

	DATE		DATE
1. REMOVED		5. TO AWP	
2. RECEIVED MATL. CONTROL		6. OFF AWP	
3. WORK STARTED		7. TO AWP	
4. COMPLETED		8. OFF AWP	
RFI ☐ B COND ☐ R/S ☐		9.	
		0.	
H. PCN	PRIORITY	DATE DUE IN	OUT

40. FAILED MATERIAL

.1 ACT TKN	.2 MAL	.3 QTY	.4 MFGR	.5 PART NUMBER/REF. SYMBOL

J. ACCUMULATED HOURS

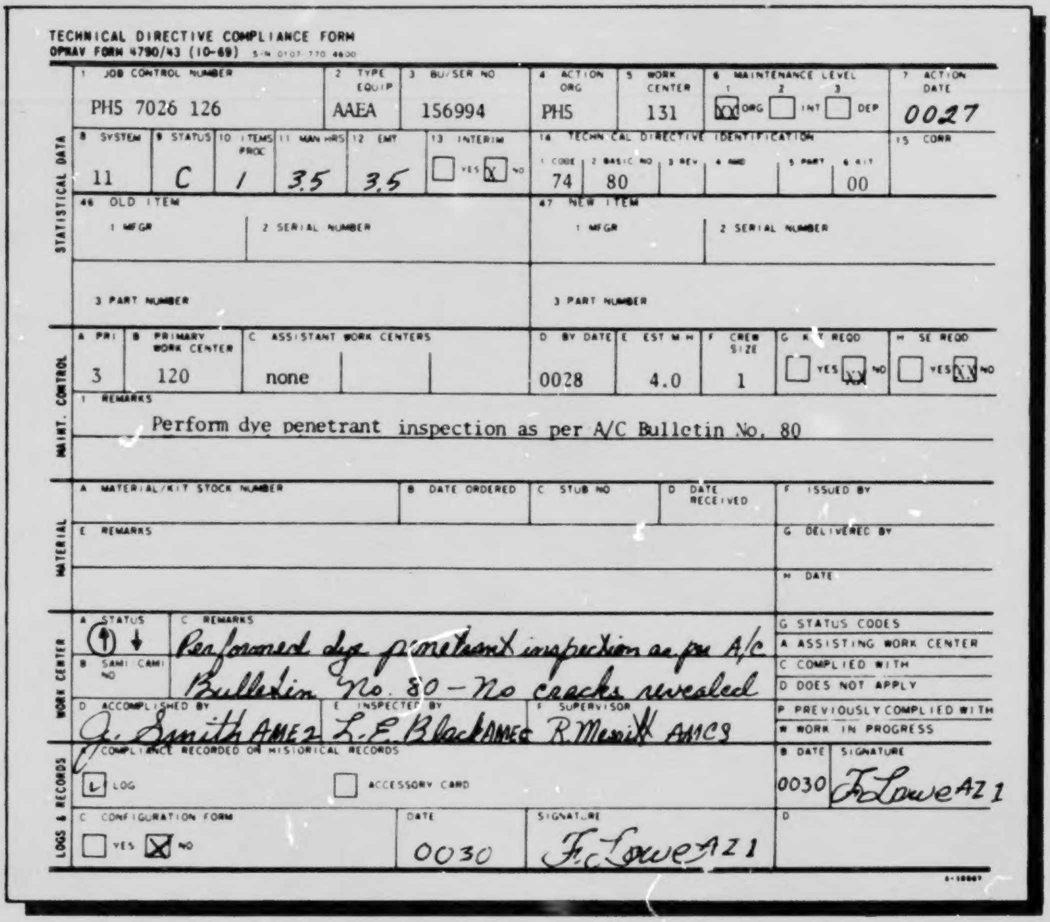
NAME/SHIFT	DATE	MAN-HOURS	EMT
TOTAL			

K. REQUIRED MATERIAL

REQ. NO.	MFGR	PART NUMBER	QTY	PRI	DATE/TIME ORD	DATE/TIME REC	AWP

AM.5

Figure 4-12.—MAF used for penetrant inspection during calendar inspection.



TECHNICAL DIRECTIVE COMPLIANCE FORM
OPNAV FORM 4790/43 (10-69) S/N 0107-770-4600

STATISTICAL DATA

1 JOB CONTROL NUMBER: PHS 7026 126
2 TYPE EQUIP: AAEA
3 BU/SER NO: 156994
4 ACTION ORG: PHS
5 WORK CENTER: 131
6 MAINTENANCE LEVEL: 1 ☒ ORG 2 ☐ INT 3 ☐ DEP
7 ACTION DATE: 0027
8 SYSTEM: 11
9 STATUS: C
10 ITEMS PROC: 1
11 MAN HRS: 3.5
12 EMT: 3.5
13 INTERIM: ☐ YES ☒ NO
14 TECHNICAL DIRECTIVE IDENTIFICATION: 1 CODE 74 2 BASIC NO 80 3 REV 4 AMD 5 PART 6 KIT 00
15 CORR
46 OLD ITEM: 1 MFGR 2 SERIAL NUMBER 3 PART NUMBER
47 NEW ITEM: 1 MFGR 2 SERIAL NUMBER 3 PART NUMBER

MAINT. CONTROL

A PRI: 3
B PRIMARY WORK CENTER: 120
C ASSISTANT WORK CENTERS: none
D BY DATE: 0028
E EST M H: 4.0
F CREW SIZE: 1
G KIT REQD: ☐ YES ☒ NO
H SE REQD: ☐ YES ☒ NO
I REMARKS: Perform dye penetrant inspection as per A/C Bulletin No. 80

MATERIAL

A MATERIAL/KIT STOCK NUMBER
B DATE ORDERED
C STUB NO
D DATE RECEIVED
E REMARKS
F ISSUED BY
G DELIVERED BY
H DATE

WORK CENTER

A STATUS: [✓ ↑] ↓
B SAMI CAMI NO
C REMARKS: Performed dye penetrant inspection as per A/C Bulletin No. 80 - No cracks revealed
D ACCOMPLISHED BY: J. Smith AME2
E INSPECTED BY: L. E. Black AME2
F SUPERVISOR: R. Merritt AMCS

G STATUS CODES
A ASSISTING WORK CENTER
C COMPLIED WITH
D DOES NOT APPLY
P PREVIOUSLY COMPLIED WITH
W WORK IN PROGRESS

LOGS & RECORDS

A COMPLIANCE RECORDED ON HISTORICAL RECORDS: ☑ L LOG ☐ ACCESSORY CARD
B DATE: 0030 SIGNATURE: F. Lowe AZ1
C CONFIGURATION FORM: ☐ YES ☒ NO
DATE: 0030
SIGNATURE: F. Lowe AZ1
D

AM.7

Figure 4-13.—TDCF documentation for penetrant inspection.

Additional paint removers are discussed in lavAir 01-1A-509 and NavAir 07-1-503. Each emover has a specific intended use. For examle, MIL-R-81294 is for removing epoxy finishes ut could be damaging to synthetic rubber, while onflammable water soluble paint remover conorming to MIL-R-18553 is usable in contact vith synthetic rubber. In all cases utilize the ecommended remover that meets the requirenents of the job being accomplished.

rocedures and Precautions

The stripping procedures provided in this ection are general in nature. When stripping any aircraft surface, consult the applicable Maintenance Instructions Manual for the specific procedures to be used.

Stripping should be accomplished outside whenever possible. If stripping must be done in a hangar or other enclosure, adequate ventilation must be assured. CAUTION: Prior to cleaning and stripping, insure that the aircraft is properly grounded to dissipate any static electricity produced by the cleaning and stripping operations.

Using approved tapes and papers, mask all seals, joints, skin laps, bonded joints, etc., where the paint remover may contact adhesives.

Apply the stripper liberally, and completely cover the surface to a depth of 1/32 to 1/16 inch, using a bristle brush. The stripper should not be spread in a thin coat like paint, since it will not loosen paint sufficiently for removal, and the remover may dry on the surface of the metal, requiring a reapplication.

Allow the stripper to remain on the surface for a sufficient length of time to wrinkle and lift the paint, which may be from 10 minutes to several hours, depending on both the temperature and humidity and the condition of the paint coat being removed. Loosened paint may be removed with fiber scrapers, bristle brushes, and rags. The surface should then be rinsed with water to remove any residual stripper.

After rinsing the area thoroughly, wipe down with rags wet with lacquer thinner or on approved solvent cleaner such as Stoddard solvent.

The next step is to remove all masking tape and carefully strip away the remaining paint it covered, using rags slightly dampened with an approved solvent cleaner such as methyl-ethyl-ketone (MEK). Use only nonmetallic scrappers to assist in removing persistent paint finishes.

CORROSION REMOVAL

After the paint has been removed from corrosion-damaged areas of metal surfaces, it is necessary to remove all corrosion deposits before an accurate assessment of damage can be made. The different corrosion removal processes required by the various aircraft metals include chemical treatments to prevent or retard future corrosive attack. These chemical treatments are discussed as a part of the corrosion removal processes in this section. Further chemical treatments are applied for the purpose of improving paint adhesion if it is determined that the corrosion damage is tolerable and the affected parts may remain in service. Prepaint treatments are discussed in a subsequent section of this chapter.

Corrosion Removal From Aluminum

There are three types of aluminum surfaces insofar as corrosion removal is concerned. They are clad, anodized, and exfoliated.

CLAD ALUMINUM SURFACES.—Pure aluminum has considerable corrosion resistance compared to aluminum alloys, but has little or no structural strength. It has been learned that an extremely thin sheet of pure aluminum laminated onto each side of an aluminum alloy sheet improves the corrosion resistance with little impairment of strength. The trade name of this aluminum laminated as originated by the Aluminum Company of America is "Alclad." From this trade name the adjective "clad" and the verb "cladding" have been derived. Not all aircraft sheet aluminum is clad, especially those alloy sheets from which small brackets, gussets, fittings, etc., are made. The pure aluminum is very soft and the fabrication processes would severely damage or destroy the clad surfaces.

To remove corrosion from clad surfaces the corroded areas should be hand polished with household abrasives such as Bon Ami or Ajax, or with a specification metal polish, MIL-P-6888. It (the specification polish) effectively removes stains and produces a high-gloss, lasting polish on unpainted clad surfaces. During the foregoing polishing operation, care must be taken to avoid unnecessary mechanical removal of the protective clad layer and the exposure of more susceptible, but stronger, aluminum alloy base.

If there is any superficial corrosion present, it should be treated by wiping down with an inhibitive material such as the Chemical Surface Films for Aluminum Alloy, available under specification MIL-C-5541A. (See Chemical Surface Treatment, this chapter.)

ANODIZED ALUMINUM SURFACES.—Anodizing is the most common surface treatment of nonclad aluminum alloy surfaces. The aluminum alloy sheet or casting is the positive pole in an electrolytic bath in which chromic acid or other oxidizing agent produces an aluminum oxide film on the metal surface. Aluminum oxide is naturally protective, and anodizing merely increases the thickness and density of the natural oxide film. When this coating is damaged in service, it can only be partially restored by chemical surface treatments. Therefore, any processing of anodized surfaces, including corrosion removal, should avoid unnecessary destruction of the oxide film.

Aluminum wool, nylon webbing impregnated with aluminum oxide abrasive, or fiber bristle brushes are the approved tools for cleaning anodized surfaces. The use of steel wool, steel wire brushes, or harsh abrasive materials on any aluminum surface is prohibited. Producing a buffed or wire brush finish by any means is also prohibited. Otherwise, anodized surfaces are treated in much the same manner as other aluminum finishes.

EXFOLIATED SURFACES.--As previously described, exfoliation is a separation along the grain boundaries of metal and is caused by intergranular corrosion. More severe procedures must be observed when intergranular corrosion is present. The mechanical removal of all corrosion products and visible delaminated metal layers must be accomplished in order to determine the extent of destruction and to evaluate the remaining structural strength of the component. Metal scrapers, rotary files, and other necessary tools are used to assure that all corrosion products are removed and that only structurally sound aluminum remains. Inspection with a 5 to 10 power magnifying glass, or the use of dye penetrant, will aid in determining if all unsound metal and corrosion products have been removed. When complete removal has been attained, any rough edges should be blended or smoothed out even though this involves the removal of more metal. Grinding, where required, can best be accomplished by using rubber base wheels into which tiny particles of aluminum oxide abrasives have been impregnated.

Chemical treatment of exposed surfaces is applied in the same manner as any other aluminum surface.

Any loss of structural strength in critical areas should be evaluated by cognizant aeronautical engineers, particularly if the damage exceeds the permissible limits established in the Structural Repair Manual for the aircraft model involved.

Corrosion Removal From Iron and Steel

The most practical means of controlling the corrosion of steel is the complete removal of the corrosion products (rust) by mechanical means. Except on highly stressed steel surfaces, the use of abrasive papers, small, power buffers (fig. 4-14) and buffing compounds, hand wire brushing, and steel wool are all acceptable cleanup procedures. It is a recognized fact, however, that in any such uses of abrasives, residual iron rust usually remains in the bottom of small pits and other surfaces. As a result, a part once rusty usually corrodes again, more easily than it did the first time.

There are approved methods for converting active iron rust to phosphates and other protective coatings; however, most of these procedures require shop installed equipment and are therefore impractical in the field. Another disadvantage of chemically inhibiting iron rust is the danger of entrapping these chemicals in installed assemblies where thorough flushing is difficult, thereby causing far more corrosion than was originally present.

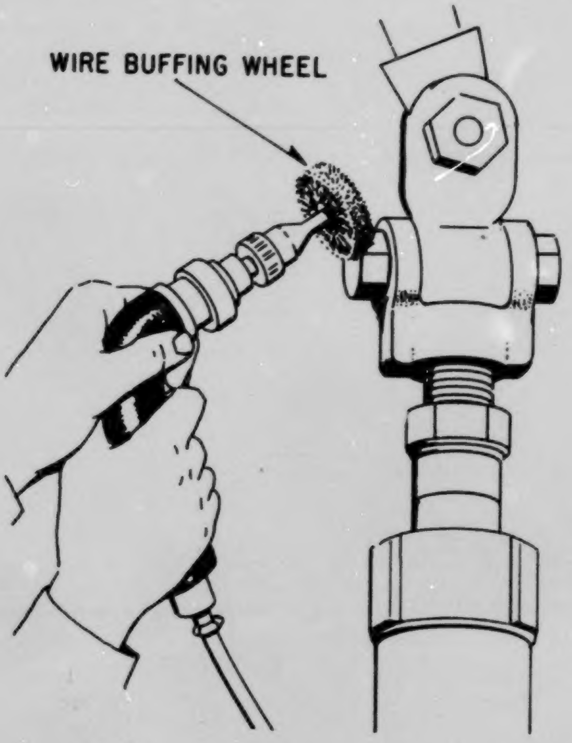


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Figure 4-14.—Corrosion removal from ordinary steel.

HIGHLY-STRESSED STEEL SURFACES.—Any corrosion on the surface of highly stressed steel is potentially dangerous, and careful removal of the corrosion deposits is mandatory. surface scratches or changes in the surface molecular structure due to overheating can cause sudden failure. Removal of corrosion products must be accomplished by careful processing, using mild abrasive papers such as fine grit aluminum oxide, or fine buffing compounds on cloth buffing wheels. It is essential that the steel surface not be overheated while buffing. After this careful removal of surface corrosion, protective paint finishes should be reapplied immediately.

CADMIUM PLATED SURFACES.—As stated previously, cadmium platings are still offering sacrificial protection even when they show mottling ranging from white to brown to black on their surfaces. This discoloration should never be removed for appearance sake alone. Not until the characteristic color peculiar to corrosion of the base metal appears should steps be taken.

Corrosion present should be removed by rubbing lightly with stainless steel wool. Under no circumstances should a wire brush, stainless or otherwise, be used on cadmium plated surfaces as these will remove more plating than corrosion. After the corrosion has been removed the affected area should be swabbed with a chromic acid solution and, after 30 to 60 seconds, rinsed with clean water and dried with clean cloths or low-pressure compressed air. The part is then ready for a protective paint coating.

Corrosion Removal From Magnesium

Magnesium corrosion reprotection involves the maximum removal of corrosion products, the partial restoration of surface coatings by chemical treatment, and a reapplication of protective coatings.

After cleaning the surface and stripping the paint, if any, as much of the corrosion products as possible should be broken loose and removed, using abrasive impregnated nylon webbing or glass beads with the Vacu-Blast Dry Honing Machine. Steel wire brushes, carborundum abrasives, or steel cutting tools should not be used. After the corrosion has been removed, treat the surface with Specification MIL-C-5541, chemical treatment solution, as outlined in the section on Chemical Surface Treatment (this chapter); then restore the protective paint film.

If extensive removal of corrosion products from a structural casting was involved, a decision from a structural engineer may be necessary in order to evaluate the adequacy of the structural strength remaining. Structural Repair Manuals for the aircraft models involved usually include tolerance limits for dimensions of critical structural members and should be referred to if any question of safety of flight is involved.

Corrosion Removal From Titanium

Titanium surfaces that show surface deterioration from the presence of salt deposits and impurities are cleaned with Specification P-D-680 solvent (Stoddard solvent), then any corrosion is removed by hand using abrasive impregnated nylon webbing and followed by final cleaning of the surface with water emulsion cleaner solution (1 part cleaner to 9 parts water).

MECHANICAL CORROSION REMOVAL BY BLASTING

Vapor blasting, soft grit blasting, and dry vacuum blasting are the most effective mechanical methods of removing corrosion with the least removal of the metal. For use on assembled aircraft, a portable unit such as the Vacu-Blast Aero Dry Honer is the most desirable.

Vacu-Blast Aero Dry Honer

The Vacu-Blast Aero Dry Honer is a portable self-contained, lightweight unit utilizing the dry vacuum return system. (Dry honing is the only authorized blasting method of removing corrosion on assembled aircraft.) With this machine the work is more visible and metal removal can be held to closer limits. The machine is air operated and can be used in shore-based or shipboard operations.

COMPONENTS.—The dry honing machine illustrated in figure 4-15 is composed of the following principal components mounted on a two-wheel carriage assembly:

1. Pneumatic system.
2. Control and regulator valve and gages.
3. Abrasive hopper (storage tank).
4. Aerator and feed tee.
5. Abrasive supply and return hoses.
6. Suction bypass line.
7. Blast gun assembly.
8. Gun set attachments.
9. Air ejector pump.
10. Abrasive reclaimer.
11. Dust collector.
12. Vibration screen.

A hose rack and storage compartment are provided on the front of the dry honing machine for storage of hoses, brushes, and accessories.

Pneumatic System.—The pneumatic system includes a main air supply connection at which is attached the external compressed-air supply,

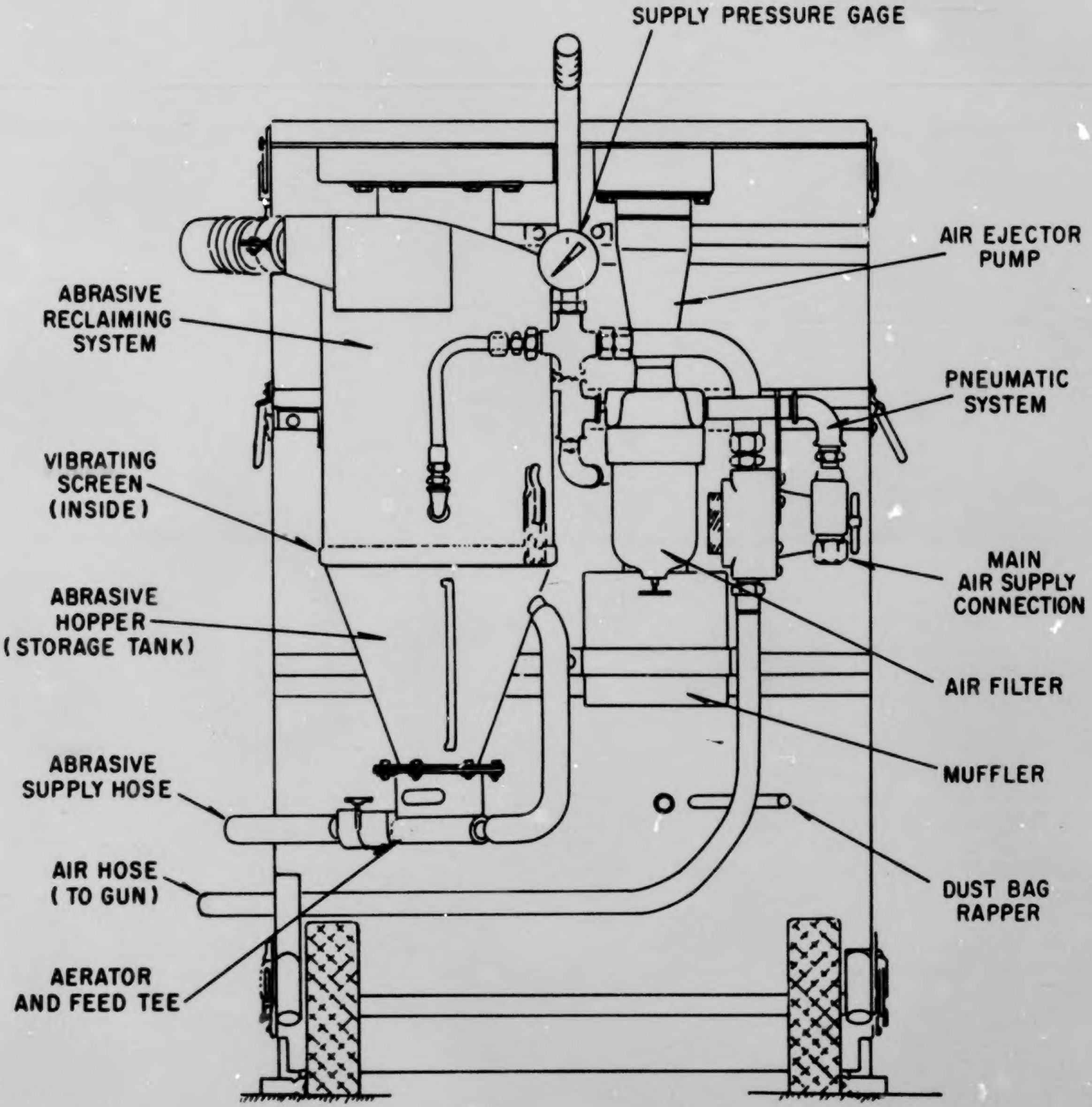
SUPPLY PRESSURE GAGE
AIR EJECTOR PUMP
ABRASIVE RECLAIMING SYSTEM
PNEUMATIC SYSTEM
VIBRATING SCREEN (INSIDE)
MAIN AIR SUPPLY CONNECTION
ABRASIVE HOPPER (STORAGE TANK)
AIR FILTER
MUFFLER
ABRASIVE SUPPLY HOSE
DUST BAG RAPPER
AIR HOSE (TO GUN)
AERATOR AND FEED TEE

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Figure 4-15.—Vacu-Blast—dry honing machine (back view).

interconnecting tubing, an air filter with a drain cock for removal of liquid from the compressed air, and an air ejector pump that creates the necessary vacuum to return the used abrasive from the blast gun assembly to the filter bags. The dry honing machine operates satisfactorily on air pressures ranging from 80 to 100 psi and airflows ranging from 80 to 90 cfm.

Control and Regulator Valves and Gages.—The supply pressure gage indicates the compressed-air supply pressure. The 150-pound maximum variable pressure regulator is operated to adjust the air supply to the desired pressure before entering the airhose to the blast gun assembly. This pressure is indicated on the blast pressure gage adjacent to the pressure regulator.

Abrasive Hopper (Storage Tank).—The abrasive storage tank is conical in shape to effect direction of flow of abrasive. It is removed by release of two spring clamps. The normal capacity of the storage tank is 5 pounds of abrasive material.

Aerator and Feed Tee.—The aerator and feed tee located at the bottom of the storage tank is designed to aerate the abrasive in the storage tank and feed it to the blast hose leading to the blast gun. The aeration is effected by mixing of air with the fine abrasive.

When the fine abrasive is aerated, debris particles which may be mixed with the abrasive, settle to the bottom of the storage tank. The abrasive is then drawn through a metering valve, from a point a short distance above the bottom of the tank, thus preventing recirculation of the debris particles. The abrasive then flows through the feed tee into the supply hose.

Abrasive Supply and Return Hoses.—The abrasive supply hose is a 20-foot length of 5/8-inch ID transparent plastic hose, which permits direct observation of abrasive flow. It is attached to the aerator and feed tee and conveys aerated abrasive to the blast gun assembly. The abrasive return hose is 20 feet long and returns used abrasive and debris from the blast gun assembly to the abrasive reclaiming system.

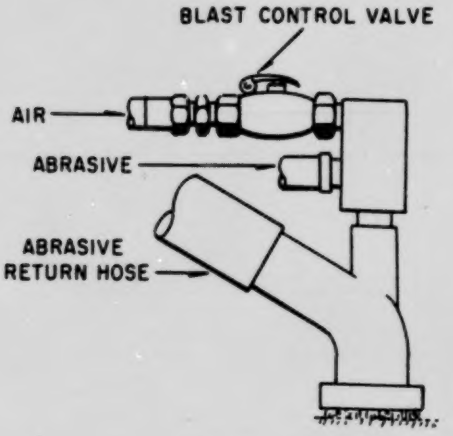
Suction Bypass Line.—The suction bypass line is designed to remove abrasive from the blast hose when the machine is shut off in order to eliminate hose surging when blasting is started again. One end of this line is connected to the feed tee opposite the blast hose connection, and the other end of the line extends up into the storage tank. This line terminates in the storage tank above the abrasive level, and the open end is protected from the abrasive by an interior baffle. When blasting stops, the exhauster remains in operation to suck air backwards through the blast gun assembly, abrasive supply hose, feed tee, and bypass line, conveying any abrasive to the hose back into the storage tank. When blasting, airflow is reversed and the bypass line insures a balanced pressure between the storage tank and the feed tee housing so that abrasive will fall freely through the feed tee into the blast hose.

Blast Gun Assembly.—The blast gun assembly (fig. 4-16) consists of a hand-held gun, blast control valve, nozzle assembly, and connections for air, abrasive supply, and return hoses. The blast gun assembly draws the abrasive material from the abrasive supply hose, accelerates the abrasive through the blast nozzle, and directs it against the workpiece. This is accomplished through the gun, which employs an education principle whereby compressed air is expended through an air jet to create a low pressure area in the gun housing, and by connecting the abrasive supply hose to the gun housing at the point where this low pressure area is created.

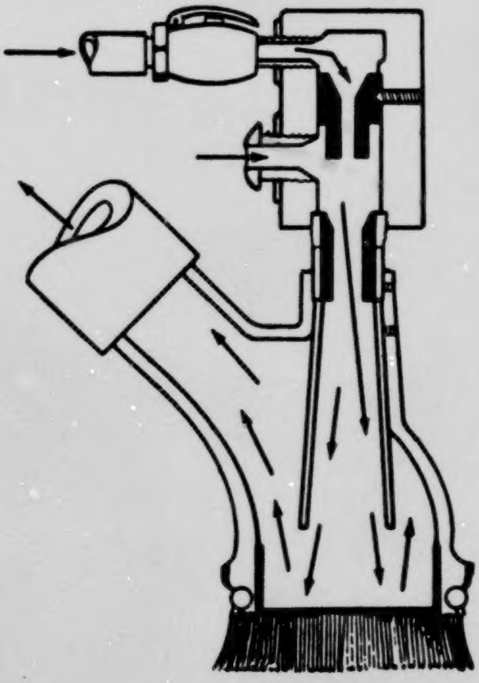
Gun Set Attachments.—The three brushes and an irregular surface attachment, illustrated in figure 4-17, are provided with the dry honing machine, and permit blasting of most surfaces. Additional care must be exercised with the inside and outside corner brushes to avoid the loss of abrasive. The irregular surface attachment will conform to most irregularities.

Air Ejector Pump.—The air ejector pump creates the necessary vacuum to return the abrasive from the blast gun assembly through the return hose to the abrasive reclaimer, carrying the dust still farther to the cloth filter bags in the dust collector.

Abrasive Reclaimer.—The abrasive reclaimer is mounted directly above the abrasive storage tank and consists essentially of a cyclone separator into which abrasive and debris (from the abrasive return hose) enter. The angle at which entry is made imparts a cyclonic, or circular, action to the airstream, causing the abrasive to drop out of suspension. The conveying airstream leaves the separator through the top, carrying with it extremely fine particles of dust which are no longer usuable as abrasive. The reclaimed abrasive itself drops to the bottom of the separator and then back through a vibrating screen section into the abrasive storage tank. Air and dust leaving the reclaimer cyclone pass into the cloth filter bag type dust collector onto which the reclaimer is mounted.



BLAST GUN ASSEMBLY



CUTAWAY VIEW

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Figure 4-16.—Blast gun assembly.

Dust Collector.—The dust collector consists of a number of cloth filter bags so arranged that dust laden air rising from the reclaimer cyclone is ducted to the bottom of the dust collector housing where it must pass through the cloth filter bags before being discharged through the exhauster. Filter bags are periodically cleaned by a manually operated bag-shaking mechanism to remove the accumulated dust which drops to the dust collector box for disposal.

Vibrating Screen.—The vibrating screen, incorporating a permanent magnet to remove steel particles, is located between the reclaimer cyclone and the abrasive storage tank. The screen is sufficiently fine to remove any oversize foreign particles from the abrasive. The vibrating screen is exposed for cleaning and inspection by dropping the abrasive storage tank. It is vibrated by an air-driven vibrator mounted at the center of the screen on a supporting frame, the amount of vibration being preset by an orifice in the air line.

ABRASIVE.—Although blasting equipment may use many types of abrasives, only glass beads are authorized for the removal of mild to medium corrosion from naval aircraft. Glass beads are manufactured of high grade optical crown glass, soda lime type.

OPERATING PROCEDURES.—The operating procedures listed in this section are general in nature. The dry honing machine must be used with care, and only by a qualified operator.

NOTE: A face shield must be worn at all times while operating the dry honing machine.

To operate the dry honer, fill the abrasive hopper with a full charge of the correct size abrasive material. Less than full abrasive charges may be used for touchup work or for dry honing either highly corroded or relatively small areas of steel. Contaminated abrasives should be thrown away after completion of the dry honing operation. No less than one-half charge (2 1/2 pounds) should ever be used.

After filling the machine with the correct abrasive, turn the regulator adjusting screw to the full open position, then turn on the external air supply valve. Set the pressure regulator to the desired pressure by placing the gun against a scrap piece of metal or rubber and operating the gun. The blast pressure can then be adjusted with the machine in operation.

Hold the blast gun firmly against the surface to be dry honed and press down on the blast control valve. Move the gun in a smooth

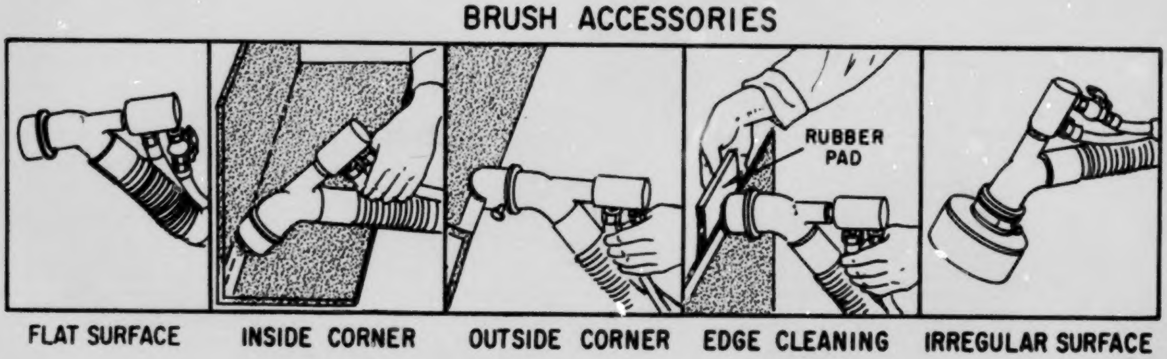

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Figure 4-17.—Gun set attachments.

pattern of overlapping strokes, advancing approximately 3/4 inch at each pass. Dwell times must be kept at a minimum necessary to produce complete corrosion removal.

CAUTION: Excessive dwell times could result in overheating of the material and/or excessive metal removal.

Smoothest reversal of direction at the end of each pass is made by moving the brush in a small circular path as shown in figure 4-18, so that the bristles roll smoothly from one direction to the other. To prevent loss of abrasive, fully release the blast control valve each time the dry honing operation is stopped and/or before the gun is raised from the surface.

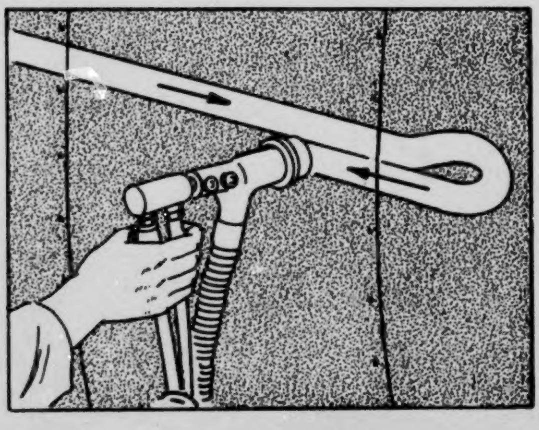

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Figure 4-18.—Proper operation of gun.

INSPECTION AND MAINTENANCE.—Certain components of the dry honing machine require inspection and maintenance at calendar or operating intervals. The two maintenance actions listed below are usually performed by the operator.

CAUTION: The main air supply must be turned off before performing any maintenance action.

Two-Hour Intervals.—At the end of each 2 hours of operation, shut off the air supply to the machine and shake down the filter bags by swinging the dust bag rapper down and sharply returning it to the normal position. Repeat this rapper action for 20 quick strokes. After shaking down the filter bags, empty the dust box.

Four-Hour Intervals.—Open the drain cock at the bottom of the air filter and drain moisture every 4 hours, or whenever visible. Additional maintenance and lubrication requirements are defined in NavAir 17-5BM-1.

CAUTION: Care must be taken to prevent damage to the plastic air filter bowl. Mechanical damage or contact with common solvents will cause it to shatter when pressurized. If necessary to clean the bowl, use only water or a mild detergent solution.

LIMITATIONS.—The dry honing machine described in the aforementioned sections can cause damage to aircraft components and systems if improperly used. Small quantities of abrasive may be expected to escape from the blast nozzle during normal use; therefore, the equipment must not be used in areas or under conditions where the abrasive may contaminate systems or components.

1. Do not use on engines, gear boxes, or other oil lubricating systems.
2. Do not use on fuel, hydraulic, or oxygen system components.
3. Mask vents of the above listed systems when blasting near them to prevent possible contamination.
4. Use only on exterior surfaces or parts which have been removed from the airframe to prevent possible contamination of interior areas.
5. Do not use on airframes skins or structural parts which are exposed to over 500° F in service.
6. Do not blast Metallite or honeycomb panels.

NOTE: Corrosion PREVENTIVE maintenance is documented on a Support Action Form, while corrosion maintenance that is considered as TREATMENT must be documented on the Maintenance Action Form so that a record of extensive corrosion rework will exist and be available for any Aircraft Logbook entries that may be required.

CORROSION DAMAGE LIMITS

The term "corrosion damage limits" refers to the amount of metal which may be removed from a corroded part and still maintain the required safe margin of strength and function. When removing corrosion, maintenance personnel must be very careful not to remove more of the metal than is absolutely necessary to insure complete removal of corrosion. Figure 4-19 illustrates the maximum corrosion depths allowed on the various components of the nose landing gear on one late model aircraft.

Damage which exceeds those limits specified in the applicable Structural Repair Manual or the Corrosion Control section of the applicable Maintenance Instructions Manual necessitates replacement of the affected part if actual structural repair of the damage is not possible or feasible.

CHEMICAL SURFACE TREATMENT

Chemical conversion coatings will increase corrosion resistance and improve paint adhesion. After cleaning and removal of any surface oxides, aluminum and magnesium should be treated with MIL-C-5541 chemical treatment. These coatings are often damaged during aircraft maintenance or are contaminated by grease, oil, or other foreign matter. Therefore, the treated surface should be painted soon after treating if best results are to be expected.

Soluble salt residues remaining on the surface after treatment will accelerate corrosion and can cause blistering of paint finishes. Thus, complete rinsing with fresh water following the chemical treatment is very important. Flush the chemical with free-flowing water only. DO NOT wipe the area with a damp cloth or brush as this will deteriorate or remove the chemical conversion coating, which is sensitive to abrasion prior to fully drying.

CAUTION: Personnel should wear goggles, aprons, and rubber gloves when using solutions of MIL-C-5541.

Chemical Conversion of Aluminum Alloys

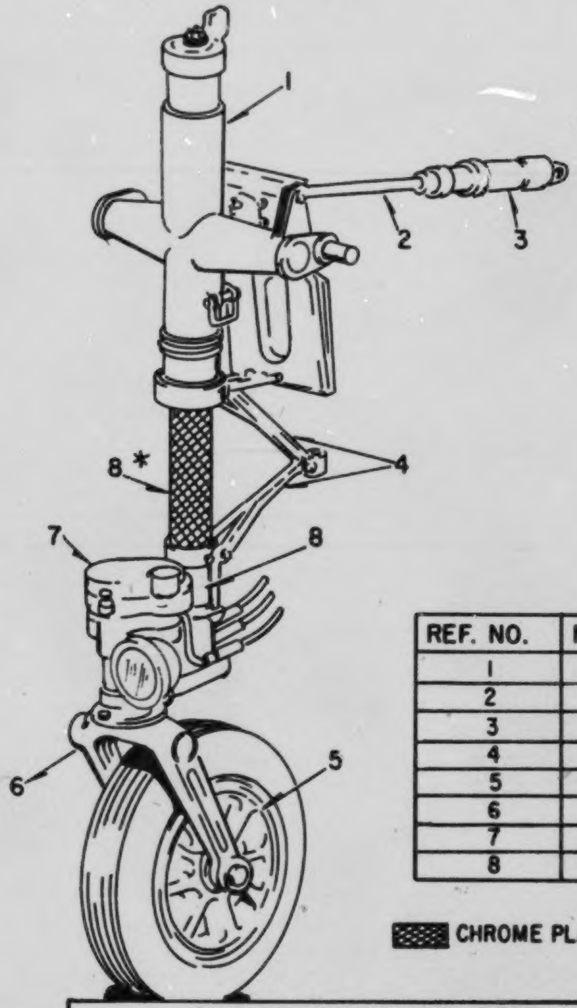
The procedure to be used for the chemical conversion of aluminum alloys is as follows:

1. Insure that the surface is clean.
2. Brush MIL-C-5541 solution on areas to be treated. Repeat application of fresh solution until a uniform irridescent yellow to brown color is produced, then discontinue brushing and allow the solution to remain on the metal for about 1 minute.
3. Rinse the complete area with fresh water.
4. Allow to air dry (usually not more than 1 hour) before priming. A powdery coating indicates poor rinsing or failure to keep the surface wet during the treatment. If this occurs, the treatment should be repeated.

NOTE: Chemical treatments conforming to Specification MIL-C-5541 are not all the same composition and therefore should be prepared for use according to the particular manufacturer's instructions.

Chemical Conversion of Magnesium Alloys

Procedure for the chemical conversion of magnesium alloys is as follows:



REF. NO.	NOMENCLATURE
1	OUTER CYLINDER
2	ACTUATOR PISTON
3	ACTUATOR BODY
4	TORQUE ARMS
5	WHEEL
6	FORK
7	STEERING UNIT
8	PISTON

▨ CHROME PLATE

MAXIMUM CORROSION DEPTH		
REF. NO.	MATERIAL	MAX DEPTH
1	ALUMINUM	0.015
2	CHR PLATED STEEL	0.003
3	ALUMINUM	0.030
4	ALUMINUM	0.030
5	MAGNESIUM	0.030
6	HEAT RESISTANT STEEL	0.010
7	HEAT RESISTANT STEEL	0.010
8	HEAT RESISTANT STEEL	0.010
8*	CHROME PLATED HEAT RESISTANT STEEL	0.004

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Figure 4-19.—A-5 nose gear—maximum corrosion depths.

1. Insure that the surface is clean.
2. While the surface is still wet, brush on MIL-C-5541 chemical treatment solution. Continue application of fresh solution on the metal until a uniform light brown color is obtained.

NOTE: The solution for magnesium is the same as used for aluminum and is made up according to the manufacturer's aluminum treatment instructions. The solution will react much more rapidly with magnesium than with aluminum.

3. Rinse thoroughly as with the aluminum treatment and allow to air dry prior to applying protective paint finishes.

Some magnesium parts in later model aircraft have been originally protected by a proprietary (held under patent) electrolytic process. The "HAE" process is identified by the brown to mottled gray appearance of the unpainted surface. "DOW 17" coatings will appear as a green to grayish green color. These coatings are generally thicker than those applied by immersion or brush method such as MIL-C-5541. The electrolytic finish cannot be restored in the field. Therefore, when failure of the coating occurs, any corrosion should be removed and the bare magnesium should be touched up with MIL-C-5541 chemical treatment solution. Care should be taken to minimize removal of the electrolytic coatings as they afford greater protection than the replacement coatings.

AIRCRAFT AND COMPONENT PAINTING AND PAINT TOUCHUP

The amount of paint touchup accomplished at the Organizational and Intermediate level will vary widely with the activity involved, the availability of facilities, and the area of operation.

The primary objective of any paint finish is the protection of exposed surfaces against deterioration. There are secondary reasons for particular paint schemes; the reduction of glare by nonspecular coatings, the use of white or light colored high-gloss finishes to reduce heat absorption, camouflage or high visibility requirements, or special identification markings. There is seldom justification for repainting for appearance sake only. A faded or stained, but well-bonded, paint finish is better than a fresh touchup treatment improperly applied over dirt, corrosion products, or other contaminants.

Complete refinishing, particularly under field conditions, should be restricted to those areas where existing paint finishes have deteriorated, through age and exposure, until they fail to perform their protective function. Renewal of special finishes and markings should also be restricted to those situations where the purpose of the special finish is not being served. However, maintenance and repair of paint finishes at the Organizational and Intermediate level is extremely important, from the evaluation of initial paint finishes at the time of aircraft receipt, through the constant surveillance and maintenance of finishes during a service tour, to the final recommendations for refinishing requirements when the aircraft is scheduled for Progressive Aircraft Rework at the Depot level of maintenance.

SURFACE PREPARATION

Much of the effectiveness of any paint finish and its adherence depends on the careful preparation of the damaged surface prior to touchup. The procedures to be used in paint and corrosion removal have been described previously. The touchup paint should overlap onto the existing good paint finish. The touchup materials will not adhere properly to glossy finishes. Also, any edges of the existing film will show through the overlap unless they are smoothed out.

To break the gloss of existing finishes and to feather (smooth out) the edges for overlap, scuff sand, using 300 to 400 aluminum oxide paper. Following sanding, a water rinse is used to remove the abrasive residues.

Next, all sanded areas and exposed bare metal surfaces are wiped down with 1-BUTANOL (normal butyl alcholol).

Remove any loosened seam sealants in the area to be touched up and replace as necessary. (See Sealants and Sealing Practices in this chapter.) Also, resecure any loose rubber seals, using the type adhesive specified in the applicable Maintenance Instructions Manual.

The area to be painted is then outlined with tape and masking paper as shown in figure 4-20. This protects the adjoining surfaces from overspray and unwanted paint buildup.

TOUCHUP PROCEDURES

In the past, it was necessary to identify the specific surface finish (paint system) applied to an aircraft at the time of manufacture or rework. Each surface finish (nitrocellulose lacquer, acrylic lacquer, and epoxy) required a specific touchup procedure that was compatible with the present finish. Failure to properly identify the present surface finish and apply the specific touchup procedures, usually resulted in wasted manhours and material.

To preclude this and more effectively control corrosion, a standardized paint system for Organizational and Intermediate level painting and paint touchup has been promulgated by the Naval Air Systems Command. This system consists of an improved expoxy primer, Specification MIL-P-23377B and an acrylic topcoat, Specification MIL-L-81352, and is compatible with all of the various systems presently used in naval aircraft.

Epoxy-Polyamide Primer
(MIL-P-23377B)

The epoxy-polyamide primer is supplied as a two-part kit, each part of which must be stirred or shaken thoroughly before mixing. One part contains the pigment, ground in an epoxy vehicle, while the other part is composed of a clear polyamide solution which functions as a hardener for the epoxy solution. This primer is supplied by various manufacturers. Mix only as much primer as needed, as the storage life of the primer is limited after mixing. CAUTION: Do not substitute part 1 or part 2 from another manufacturer. Established mixing ratios supplied by the manufacturer must be followed, otherwise the primer will exhibit unsatisfactory properties, such as poor adhesion, poor chemical resistance, or inadequately dried film.

For mixing, pour the specified amount of part 1 into an empty container, then slowly pour part 2 into the container, stirring constantly. CAUTION: Always add part 2 to part 1.

To thin the primer for spraying, add 1 1/2 parts thinner, Specification MIL-T-19588, to 2 parts primer. The thinned primer should be stirred thoroughly, strained, and allowed to stand 1 hour prior to use. If necessary the thinning ratio may be varied slightly to obtain the proper spraying viscosity. The 1-hour standing time is necessary to permit the components to enter into chemical reaction, shorten drying time, reduce cratering, preclude part 2 from "sweating out" or migrating, and to allow any bubbles (formed while stirring) to escape.

To apply the primer, insure that the surface to be primed has been cleaned, chemically treated, and prepared for spraying as previously described in this section. Apply a wet coat of epoxy primer to 1 mil thickness and allow to dry from 1 to 2 hours. One hour is sufficient when temperature and humidity range is ideal.

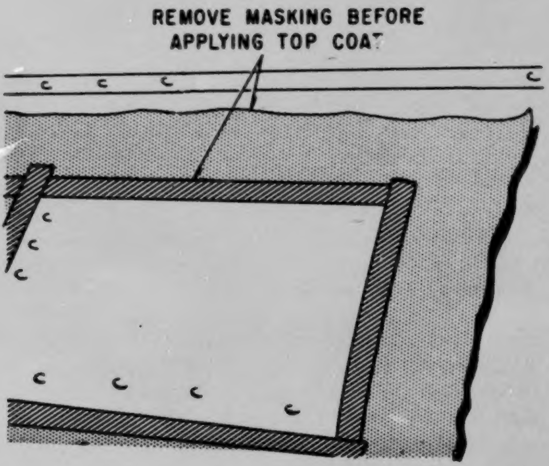

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Figure 4-20.—Masking prior to paint touchup.

Acrylic Lacquer Topcoat
(MIL-L-81352)

This acrylic lacquer is used as a general purpose external coating for metal surfaces. It is applied directly over the epoxy-polyamide primer. It is available in all colors for touchup and insignia marking directly over all paint systems presently employed on naval aircraft.

To thin the acrylic lacquer topcoat for spraying, mix 1 volume of lacquer with approximately 1 1/2 volumes of thinner. The thinner used with this lacquer is composed of equal parts by volume of toluene and xylene. The exact thinning ratio must be determined by the user and adjusted to the prevailing temperature, relative humidity, and type of spraying equipment being used. Increasing the xylene portion promotes better flowout and reduces dry spray but also prolongs drying time.

After thinning the acrylic lacquer to spraying viscosity, it should be applied in two spray coats with a 30-minute air-dry interval between coats. The total dry film thickness of the acrylic topcoat should be 0.8 to 1.2 mils.

To apply insignia and/or squadron markings over the acrylic topcoat, begin masking after the coating has dried tack-free. Apply the tape with a minimum of pressure to avoid marking and possible damage to the topcoat. The insignia and/or markings are then applied directly over the topcoat. NOTE: Do not use epoxy primer when repainting or doing touchup work over Specification MIL-L-81352 acrylic lacquer topcoat.

When painting insignia and/or squadron markings over all other paint systems, use the epoxy primer and then overcoat with the acrylic lacquer.

CAUTION: The materials used for painting and paint touchup are toxic and flammable. Precautions must be taken to assure respiratory (face mask) and eye protection for personnel engaged in mixing and spraying paint and/or primers. Gloves and aprons should also be used to prevent skin contact. The mixing and application of paints and primers should be done in well-ventilated spaces only.

Paint touchup in the field is a difficult task. Table 4-2 lists some of the problems encountered during paint application, the most probable cause, and methods for correction.

Enamel Finishes

Most enamel finishes used on aircraft surfaces are baked finishes that cannot be touched up with the same materials in the field.

Minor damage to conventional enamel finishes ordinarily used on engine housings is repaired by touching up with epoxy topcoat material or air-drying enamel.

SEALANTS AND SEALING PRACTICES

Sealants are used to prevent the movement of liquid or gas from one point to another. They are used in an aircraft to maintain pressurization in cabin areas, to retain fuel in storage areas, to achieve exterior surface aerodynamic smoothness, and to weatherproof the airframe.

Sealants are used in general repair work in the field and for maintenance and restoration of seam integrity in critical areas if structural damage or the use of paint removers has loosened existing sealants.

Conditions surrounding the requirements for use of sealants govern the type of sealants to be used. Some sealants are exposed to extremely high and/or low temperatures. Other sealants are in contact with fuels, lubricants, etc. Therefore, it is necessary that sealants be used which have beeen compounded for that particular type of usage. These sealants are supplied in different consistencies and rates of cure. The basic types of sealants are classified in three general categories—Pliable Sealants, Drying Sealants, and Curing Sealants.

PLIABLE SEALANTS

These sealants are referred to as one-part and are supplied ready for use as packaged. They are solids and change little, if any, during or after application. Solvent is not used in this type. Therefore, drying is not necessary; and except for normal aging, they remain virtually the same as when first packaged, neither hardening nor shrinking. The adhesion to metal, glass, and plastic surfaces is excellent. Pliable sealants are used around high-usage access panels and doors, and in areas where pressurization cavities must be maintained.

DRYING SEALANTS

Drying sealants set and cure by evaporation of the solvent. Solvents are used in these sealants to provide the desired consistency for application. Consistency or hardness may change little or much when this type sealant dries, depending on the amount of solvent it contains. Shrinkage upon drying is another important consideration, and the degree of shrinkage is dependent upon the proportion of solvents.

CURING SEALANTS

Catalyst-cured sealants have obvious advantages over drying sealants because they are transformed from a fluid or semifluid state into a solid mass by chemical reaction or physical change, rather than by evaporation of a solvent. A chemical catalyst or "accelerator" is added and thoroughly mixed just prior to sealant applications. Heat may or may not be employed to speed up the curing process. When using a catalyst, accurate proportioning and thorough mixing of the two components are vitally important to assure a complete and even cure.

APPLICATION OF SEALANTS

Application of sealants varies according to time elements, tools required, and the method

Table 4-2.—Acrylic topcoat application, possible defects and methods for correction.

Problem	Cause/Correction
Webbing.	1. Insufficient thinning.
Dry spray.	1. Insufficient thinning. 2. Increase the proportion of the slower evaporating xylene in the xylene-toluene mixture.
Orangepeel or poor flowout.	1. Insufficient thinning. 2. Increase the proportion of the slower evaporating xylene in the xylene-toluene mixture. 3. Poor spray technique.
Slow drying.	1. Increase the proportion of faster evaporating toluene in the xylene-toluene blend.
Bleeding through or lifting of primer.	1. Allow epoxy primer to dry longer. 2. First coat of lacquer topcoat was applied too wet (first coat can also be misted on). 3. Too rich solvents used to reduce lacquer topcoat; decrease proportion of thinner.

of application. However, the following restrictions apply to all sealant applicants:

1. Sealant should be used within the approximate application time limits specified by the sealant manufacturer.

2. Sealant should not be applied to metal which is colder than 70° F. Better adhesion is obtained and the applied sealant will have less tendency to flow out of place while curing if the metal is warmed to a temperature of 90° to 100° F before the sealant is applied.

3. Sealant should be discarded immediately when it becomes too stiff to apply or work readily. Stiff or partially cured sealant will not wet the surface to which it is to be applied as well as fresh material and, consequently, will not have satisfactory adhesion.

4. Sealant should not be used for faying surface applications unless it has just been removed from refrigerated storage or freshly mixed.

When pressure sealing an aircraft, the sealing materials should be applied in such a manner as to produce a continuous bead, film, or fillet over the sealed area. Air bubbles, voids, metal chips, or oily contamination will prevent an effective seal. Therefore, the success of the sealing operation depends upon the cleanliness of the area and the careful application of the sealant materials.

There are various methods of pressure sealing joints and seams in aircraft. The applicable Structural Repair Manual will specify the method to be used in each application.

The sealing of a faying surface is accomplished by brush coating the contacting surfaces with the specified sealant. The application of the sealant should be made immediately before fastening the parts together.

Careful planning and arrangement of work and equipment are necessary in order that faying surface seals on large assemblies may be closed within the application time limit of the sealant. Once the sealant has been applied, the parts must be joined, the required number of bolts must be torqued, and all the rivets driven within this time limit.

When insulating tape has been installed between the faying surfaces to prevent dissimilar metals contacts, pressure sealing should be accomplished by fillet sealing.

Fillet sealing is accomplished by spreading the specified sealant along the seam with a sealant injection gun. The sealant should be spread in approximately 3-foot increments. Before proceeding to the next increment, the applied portion of the fillet should be worked in with a sealant spatula or tool. (See fig. 4-21.) This working of the sealant is done to fill in all voids in the seam and to eliminate as many air bubbles as possible. The leak-free service life of the sealant is determined by the thoroughness and care used in working out the air bubbles.

After the sealant has cured to a tack-free condition, the fillet should be inspected for any remaining air bubbles. Such air bubbles should be opened up and filled with sealant.

When a heavy fillet is required it should be applied in layers and the top layer should fair with the metal.

Injection sealing is the pressure filling of openings or voids with a sealant injection gun. Joggles should be filled by forcing sealant into the opening until it emerges from the opposite side. Voids and cavities are filled by starting with the nozzle of the sealant injection gun at the bottom of the space and filling as the nozzle is withdrawn.

Fasteners such as rivets, Rivnuts, screws, and small bolts should have a brush coat of sealant over the protruding portion on the pressure side. Washers should have a brush coat of sealant on both sides. Split type grommets should have sealant brushed into the split prior to installation. After installation, fillets should be applied to both the base of the grommet and the protruding tube on the pressure side.

Temperatue Resistant Sealing Compound (MIL-S-8802)

Sealant conforming to Specification MIL-S-8802 is the most widely recommended sealant for sealing aircraft depressions, gaps, seams, and faying surfaces of high performance aircraft. It is a synthetic base sealant with a separate catalyst. It should be mixed in accordance with the manufacturer's instructions. The viscosity and working time is affected by temperature and humidity. Higher temperatures and humidity increase the viscosity and decrease the working time for application. Through experience it will be learned how much should be mixed for use in the time before it becomes unworkable.

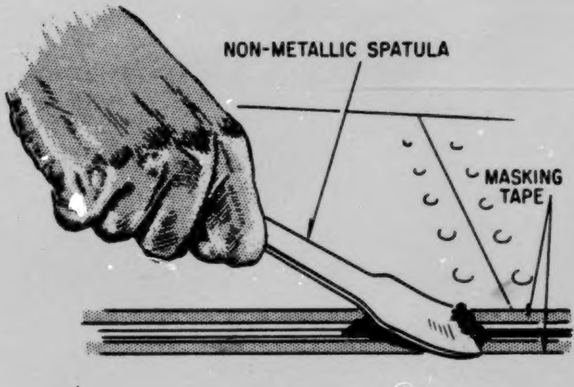

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Figure 4-21.—Applying sealant.

Treated and cleaned areas that require sealing should not be contaminated with hands, tools, or other foreign objects. The sealant is applied between tape and worked into the recess as shown in figure 4-21. Smoothing of the sealant will be easier if the spatula is dipped in water prior to use. The tape should be removed immediately after the sealant has been applied and before it begins to set. The sealant may be overpainted immediately after removal of the tape.

SAFETY PRECUATIONS

Many of the sealants listed above may be flammable and/or may produce toxic vapors. When using any material designated as flammable, all sources of ignition must be at least 50 feet away from the location of the work. Toxic vapors are produced by the evaporation of solvents and/or the chemical reaction taking place in the curing sealants. When using sealants in confined spaces such as fuel cells, fuselage or wing sections, table or bench operations, etc., adequate local exhaust ventilation must be used to reduce the vapors below the maximum allowable concentration, and kept at that level until repairs have been completed. Do not eat or smoke when working with sealants.

CHAPTER 5

PRESSURIZATION AND AIR-CONDITIONING SYSTEMS

Transferring a human being from his natural environment on the earth's surface to the environment existing at 40,000 feet places him in surroundings in which he cannot survive without artificial aids. Even at half that altitude breathing becomes very rapid; and above 25,000 feet unconsciousness occurs, quickly followed by death. A brief study of the earth's atmosphere tells us why this condition exists.

STRUCTURE OF THE ATMOSPHERE

The envelope of atmosphere surrounding the earth is a gaseous mixture consisting chiefly of nitrogen and oxygen. There are traces of other gases, but they have no significance as far as body functions are concerned. Chemical analysis has shown that the proportions of nitrogen and oxygen are constant throughout the thickness of the atmosphere, up through 200,000 feet or more.

ATMOSPHERIC PRESSURE

Although the chemical content of the atmosphere remains fairly constant, the density (mass per unit volume) of the atmosphere varies with the altitude. At 18,000 feet the density is about one-half of the density at sea level, and at 36,000 feet it is only about one-fourth of the density at sea level. The atmospheric pressure also varies with the altitude. The pressure exerted by the atmosphere may be compared to the pressure of a column of water. If holes are made in the container of the column, the force with which the water spurts out of the upper holes will be considerably less than that at the bottom of the column. Similarly, the pressure exerted by the atmosphere is much greater near the surface of the earth than it is at high altitudes. For example, the pressure of the atmosphere at sea level is 14.7 psi, while the pressure at 40,000 feet above sea level is 2.72 psi and at 60,000 feet is 1 psi.

As an aircraft ascends to higher altitude, the resulting decrease in atmospheric pressure may affect flight personnel in several ways. The most noticeable effect is in breathing.

Breathing is a mechanical process that depends entirely on atmospheric pressure. When a person inhales, he automatically raises his ribs and depresses his diaphragm so that the chest cavity is enlarged. This reduces the air pressure within the cavity below that of the atmosphere outside. Air is thus pushed into the lungs. When he exhales, he reduces the chest cavity, increasing the pressure within it. This pushes the air out of the lungs.

When low atmospheric pressures are encountered, the lungs are not filled so completely when inhaling. With lower density, a person gets fewer molecules of air in each breath. If he gets fewer molecules of air in each breath, he also gets fewer molecules of oxygen, and no person can live unless he gets a sufficient amount of oxygen.

This problem may be solved up to certain altitudes by the proper use of oxygen equipment; however, at extremely high altitudes (above 35,000 feet), the atmospheric pressure is so low that the pressure of the blood and other liquids in the body are no longer balanced. The human body then tends to burst. In some cases, blood vessels near the surface may be ruptured, causing hemorrhages in the ears, eyes, and breathing passages.

The outside air temperature also changes with altitude. For example, at approximately 18,000 feet the outside air temperature will be -4° F (-20° C), and at approximately 37,000 feet the outside air temperature will be -67° F (-55° C). Above 37,000 feet the air continues to thin, but the air temperature will remain constant for several miles and then begin to rise slowly. Thus, the lowest outside air temperature to be encountered by an aircraft would occur at a height of about 7 miles.

NOTE: The conversion formula for converting Fahrenheit to Celsius (centigrade) is $\frac{5}{9}$ (F-32)

For example, -4° F is converted thusly:

$$\frac{5}{9}(-4 - 32) = \frac{5}{9} \text{ of } -36 = -20° \text{ C}$$

Conversion of a Celsius temperature to a Fahrenheit reading is accomplished using the following formula:

$$\frac{9}{5} \text{ C} + 32$$

For example -55° C is converted thusly:

$$\frac{9}{5} -55 + 32 = -99 + 32 = -67° \text{ F}$$

Remember not to drop the + and - signs when converting.

These variations in outside air temperature and atmospheric pressure must be considered by the aircraft manufacturer when designing the aircraft.

ATMOSPHERIC CONSIDERATIONS

Pressurization

With operational ceilings now in excess of 50,000 feet, flight personnel, and in some cases aircraft components, must be supplied with an artificial means of maintaining a reasonable pressure around the entire body and/or equipment. This is done by sealing off the entire cabin/cockpit and any equipment area that may require pressurization and maintaining an inside air pressure equivalent to that at substantially lower altitudes. This is known as the pressurized cabin, cockpit, or compartment, as applicable.

Air Conditioning

In addition to pressurizing, the cabin or cockpit and some compartments must also be air conditioned if the aircraft is to fly at high speeds. This requirement is partly due to the difference in temperatures at various altitudes and also aerodynamic heating. For example, an aircraft flying at supersonic speeds at an altitude of 35,000 feet may generate a temperature on its skin of 200° F, and twice that temperature at altitudes near sea level.

In addition to aerodynamic heating, other factors affecting cabin/cockpit temperatures are engine heat, heat from the sunrays (solar heat), heat from the electrical units, and heat from the body. Through research and tests, it has been determined that the average total temperature of these five heat sources will raise the cabin/cockpit temperature to approximately 190° F. Through experiments it has been determined that the maximum temperature that a man can withstand and maintain efficiency for extended periods is 80° F; therefore, air conditioning of the cabin/cockpit area is just as essential as pressurization. Furthermore, under low-speed operating conditions at low temperature, cabin/cockpit heating may be required.

The proper operation of much of the present day aircraft's electronic equipment is also dependent on maintaining a reasonable operating temperature that will prolong the life of various components. In most cases equipment cooling is provided by teeing off with ducting from the cabin/cockpit system. On other aircraft a separate cooling system may be utilized primarily for equipment cooling. Due to the similarity of most electronic equipment cooling components (air cycle type), only the cabin/cockpit cooling components are discussed in this section. An example of a liquid cooling system for electronic equipment cooling is provided in chapter 6.

BASIC PRESSURIZATION AND AIR—CONDITIONING SYSTEM REQUIREMENTS

This combined pressurizing and air conditioning of the cabin is the function of the aircraft pressurization and air-conditioning system, a system now incorporated on all high-speed, high-altitude aircraft. The inspection and maintenance of this system is one of the important duties of the AME. A careful study of this chapter will aid in a better understanding of the operation, inspection, and maintenance of any such system encountered.

BASIC SYSTEM REQUIREMENTS

There are five requirements necessary for the successful functioning of a pressurization and air-conditioning system. They are as follows:

1. The cabin must be designed to withstand the necessary pressure differential. This is primarily an airframe engineering and manufacturing problem.

2. An adequate supply of compressed air. This is provided by either a compressor (supercharger) or air from the compressor section of the jet engine. A compressor or supercharger is used on aircraft having reciprocating engines. On all jet aircraft, the air is taken from the compressor section of the jet engine. This is generally referred to as bleed air.

3. A means of controlling the cabin pressure. This is provided by the cabin pressure regulator which regulates the outflow of air from the cabin.

4. A means of limiting the maximum pressure differential to which the cabin walls will be subjected. This is provided for by the cabin safety valve.

5. A means of conditioning the compressed air before it enters the cabin. This is provided for by an aircraft refrigeration unit.

In addition to the above-mentioned major components, various valves, controls, and other allied units are necessary to complete an aircraft pressurization and air-conditioning system. The design, construction, and use of certain components may vary somewhat with different manufacturers; however, the systems on all jet type aircraft operate on the same principle.

TYPICAL PRESSURIZATION AND AIR CYCLE AIR-CONDITIONING SYSTEM

The environmental control system of most aircraft include cabin air conditioning and pressurization, equipment cooling, defogging, windshield washing and rain removal, and equipment pressurization subsystems.

Coverage in this section is limited to cabin and equipment pressurization and air conditioning with the remaining subsystems being covered later in this manual as utility type systems.

DESCRIPTION AND OPERATION

Figure 5-1 is a schematic diagram of a pressurization and air cycle air-conditioning system. The exact details of this system are peculiar to only one model of aircraft, but the general concept is similar to the majority of naval aircraft.

As shown in the diagram, the system is supplied by bleed air from the compressor section of either or both engines. The maximum temperature of this bleed air as it comes off the engine is approximately 800° F, and the maximum pressure is 250 psi. Expansion joints (bellows) in the system ducting allow the ducting to expand or contract with various temperature changes.

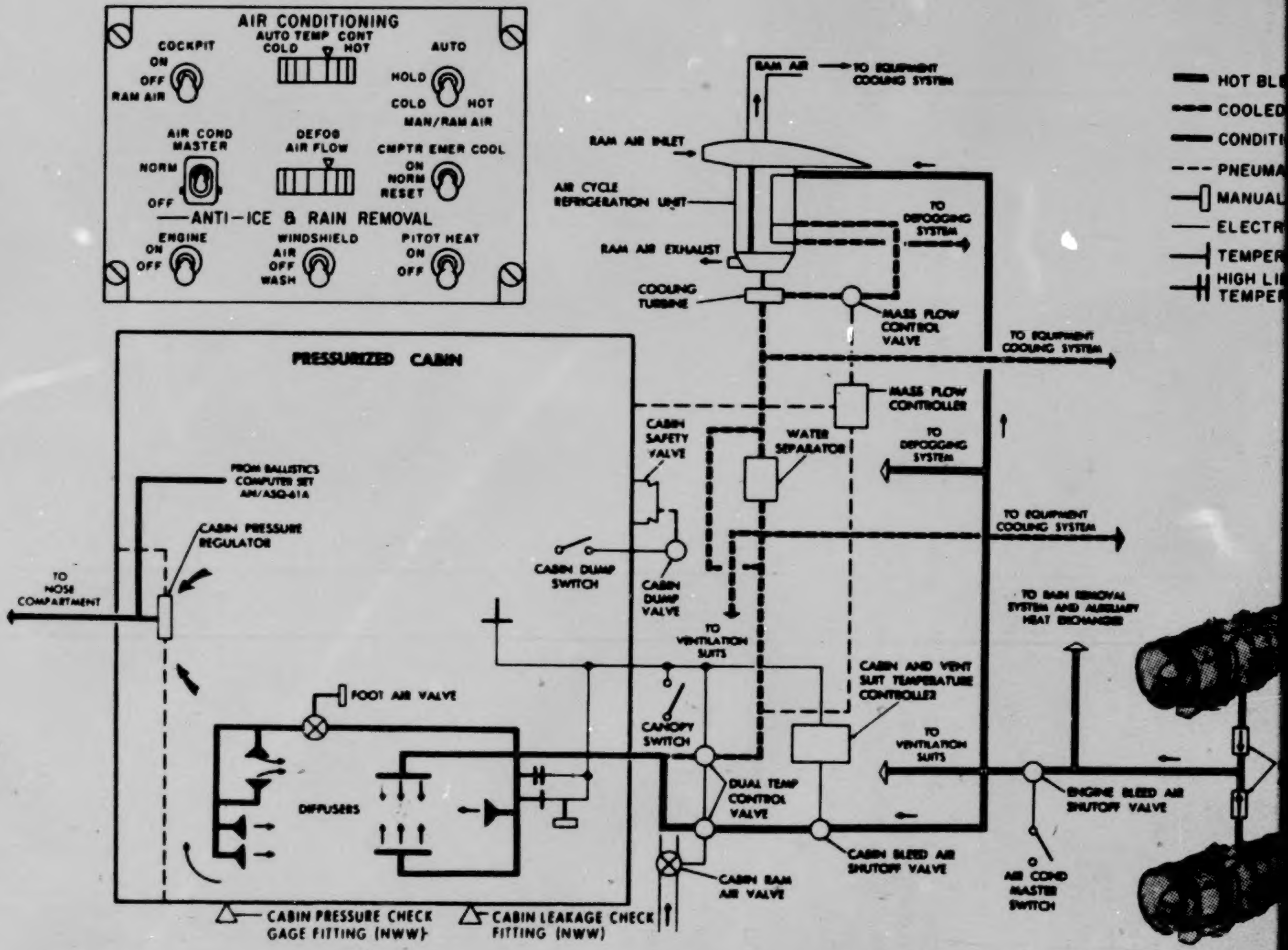
The two engine bleed-air check valves, installed in the bleed-air line from each engine, prevent bleed air from flowing from one engine to the other when one engine is not operating. They are spring-loaded, flapper type check valves.

The bleed-air shutoff valve, which is controlled by the AIR COND MASTER switch, shuts off the supply of bleed air to the main heat exchanger.

The air cycle refrigeration unit consists of the main and auxiliary heat exchangers, a cooling turbine and a fan which are mounted on a common shaft, and a mass flow control valve. Bleed air passes through both heat exchangers. Ram air enters through an air scoop, located on the right wing fillet; circulates around the fins of the heat exchangers, extracting heat from the bleed air; and is routed overboard. Part of the cooled bleed air exiting from the main heat exchanger is used for defogging; part is sent through the flow-regulating mass flow control valve to drive the cooling turbine. The bleed air in driving the cooling turbine is further cooled. The turbine, because of the common shaft arrangement, drives the fan, which aids the intake of ram air.

Part of the cold bleed air discharging from the air cycle refrigeration unit turbine is passed through the water separator. The water separator removes 80 to 90 percent of the moisture from the airstream and thus provides humidity control for air going to the cabin, ventilation suits, and electronic equipment, all of which are susceptible to damage by excessive humidity. The water separator is used to its full capacity to dry air being sent to all of these areas except the cabin. Since so high a degree of dehumidification is not required for the cabin air, a bypass is provided around the separator, so that cold air supplied to the cabin is a mixture of turbine discharge and water separator discharge air.

Under certain conditions, cooling turbine discharge air could drop below freezing. If condensation were allowed to occur, it would immediately become ice, which could quickly clog the separator and cause a reduction of cold-air flow from the separator. To prevent this, a screen is installed across the turbine discharge outlet. All discharge air must pass through this screen, and moisture will freeze on the screen


AIR CONDITIONING
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TO EQUIPMENT COOLING SYSTEM
RAM AIR INLET
AIR CYCLE REFRIGERATION UNIT
TO DEFOGGING SYSTEM
RAM AIR EXHAUST
COOLING TURBINE
MASS FLOW CONTROL VALVE
TO EQUIPMENT COOLING SYSTEM
MASS FLOW CONTROLLER
TO DEFOGGING SYSTEM
WATER SEPARATOR
CABIN SAFETY VALVE
TO EQUIPMENT COOLING SYSTEM
PRESSURIZED CABIN
FROM BALLISTICS COMPUTER SET AN/ASQ-61A
CABIN PRESSURE REGULATOR
TO NOSE COMPARTMENT
CABIN DUMP SWITCH
CABIN DUMP VALVE
TO VENTILATION SUITS
TO RAIN REMOVAL SYSTEM AND AUXILIARY HEAT EXCHANGER
CABIN AND VENT SUIT TEMPERATURE CONTROLLER
FOOT AIR VALVE
CANOPY SWITCH
DIFFUSERS
TO VENTILATION SUITS
DUAL TEMP CONTROL VALVE
ENGINE BLEED AIR SHUTOFF VALVE
CABIN BLEED AIR SHUTOFF VALVE
CABIN RAM AIR VALVE
AIR COND MASTER SWITCH
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CABIN LEAKAGE CHECK FITTING (NWW)
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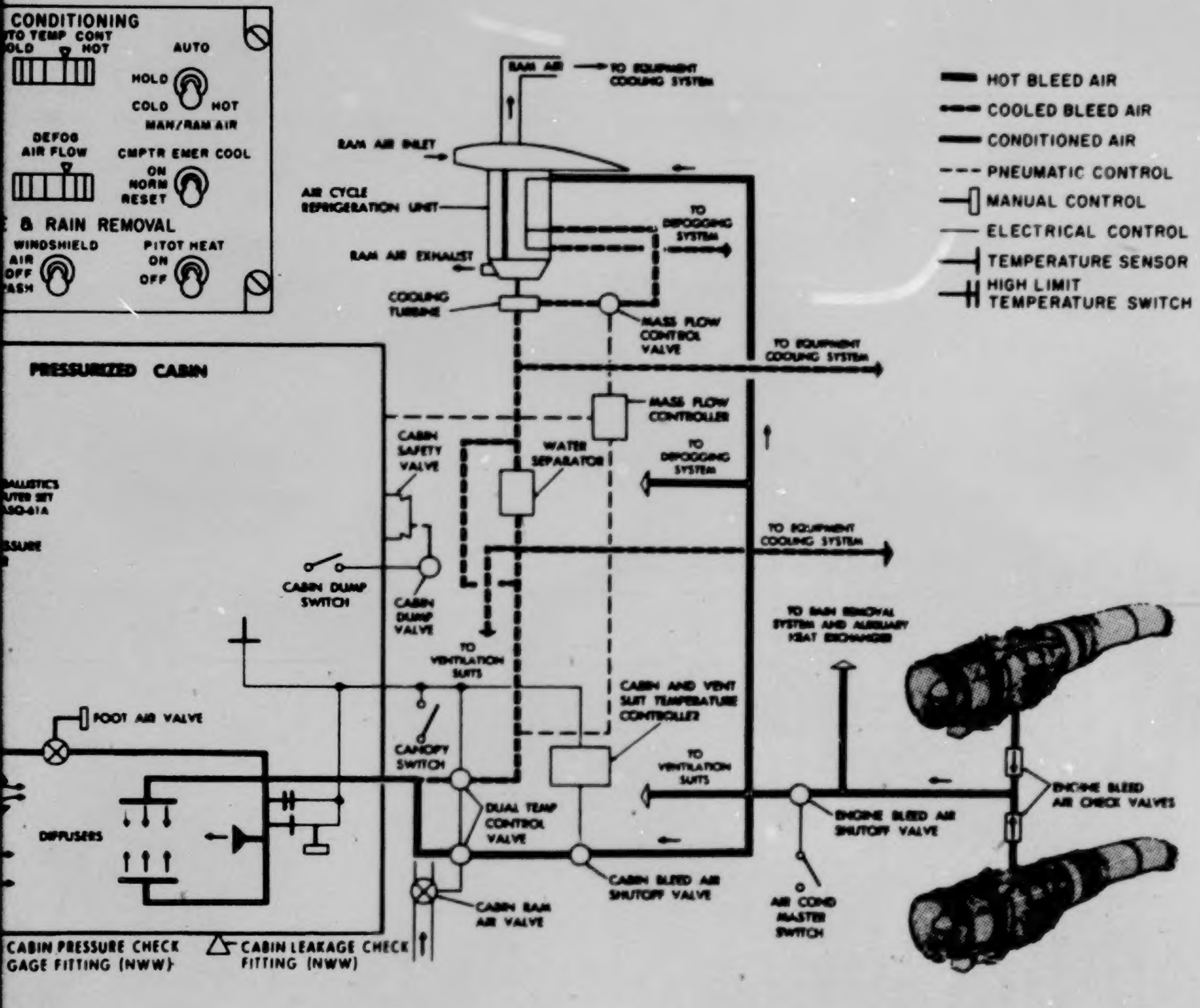
Figure 5-1.—Typical pressurization and air cycle air-conditioning system (A-6A).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AIR CYCLE REFRIGERATION UNIT
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CABIN DUMP SWITCH
CABIN DUMP VALVE
TO VENTILATION SUITS
TO RAIN REMOVAL SYSTEM AND AUXILIARY HEAT EXCHANGER
CABIN AND VENT SUIT TEMPERATURE CONTROLLER
FOOT AIR VALVE
CANOPY SWITCH
TO VENTILATION SUITS
ENGINE BLEED AIR CHECK VALVES
DIFFUSERS
DUAL TEMP CONTROL VALVE
ENGINE BLEED AIR SHUTOFF VALVE
CABIN BLEED AIR SHUTOFF VALVE
CABIN RAM AIR VALVE
AIR COND MASTER SWITCH
CABIN PRESSURE CHECK GAGE FITTING (NWW)
CABIN LEAKAGE CHECK FITTING (NWW)
HOT BLEED AIR
COOLED BLEED AIR
CONDITIONED AIR
PNEUMATIC CONTROL
MANUAL CONTROL
ELECTRICAL CONTROL
TEMPERATURE SENSOR
HIGH LIMIT TEMPERATURE SWITCH

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igure 5-1.—Typical pressurization and air cycle air-conditioning system (A-6A).

when the temperature of turbine outlet air drops below the freezing level. The formation of ice on the screen causes a back pressure, and the temperature of the air will increase accordingly. Thus the screen automatically maintains the turbine discharge temperature at 32° F or at the dewpoint temperature when dewpoint is below freezing.

The cooled air that is sent to the various areas and components through the aircraft is mixed with controlled quantities of hot engine bleed air by servocontrolled valves in each bleed-air line. These valves operate in response to temperature signals sensed by temperature sensors located at critical points throughout the conditioned airflows. The two temperature controllers, defog and equipment cooling temperature controller and cabin and ventilation suit temperature controller, provide for automatic temperature control of the conditioned air. High limit temperature switches automatically close the valves in the bleed-air lines when the conditioned air temperature reaches unsafe upper limits.

The mass flow controller regulates the mass flow control valve and subsequently controls the airflow from the cooling turbine. The mass flow control valve aids the dual temperature control valve, which is located further downstream after the water separator, to control cabin temperature. Operation of this component is discussed later.

Cabin air conditioning is controlled automatically or manually by manipulation of the switches and the thumbwheel control variable resistor located on the air-conditioning master control panel.

In the automatic mode of operation, the air-conditioning master switch is positioned at NORM, the COCKPIT switch ON, and the MAN/RAM AIR switch at AUTO. The cabin temperature desired is manually selected by adjusting the AUTO TEMP CONT thumbwheel. Temperature will be maintained within a range of 55° to 85° F. Temperature sensors in the cabin and cabin air duct transmit temperature signals through the cabin and vent suit temperature controller to the dual temperature control valve.

The sensors, one in the cabin and one in the ducting, sense actual cockpit temperature and the duct temperature of incoming conditioned air. The sensors thus provide the correct error signal through the controller to the dual temperature control valve and open and close the hot and cold line valves to provide automatically regulated temperature. If the cabin air supply duct temperature exceeds 280° F, it is detected by the cabin duct dual temperature sensor, which causes the cabin duct thermal switch to close. The switch closing causes the dual temperature control valve to cycle to the full cold position. The system will be returned to automatic control when the temperature is reduced to less than 280° F.

Manual control is accomplished by means of the MAN/RAM AIR switch. Moving this switch from the HOLD position to HOT or COLD controls the flow of conditioned air to the cockpit by altering the position of the dual temperature control valve. Positioning of the switch at HOT or COLD is momentary and the cooling-air flow will increase or decrease only as long as the switch is held in position. When released, it returns to the HOLD position and the dual temperature control valve will remain in the selected position.

Ram-air cooling/ventilation is selected by positioning the COCKPIT switch at RAM AIR. This closes the cabin bleed-air shutoff valve and cycles the dual temperature control valve to the full hot position, effectively shutting off all flow of conditioned air to the cockpit compartment. Positioning of the MAN/RAM AIR switch momentarily to HOT or COLD with the cockpit switch at the RAM AIR position opens or closes the cabin ram-air valve to increase or decrease the flow of ram air into the cockpit.

The air used to cool or heat the cockpit enters at sufficient pressure to provide cockpit pressurization. Automatic cockpit pressurization begins at 8,000 feet (barometric altitude). As the aircraft climbs, the cabin pressure regulator maintains the cockpit pressure at the 8,000-foot pressure level until a pressure differential of 5 psi between cockpit pressure and ambient pressure is reached. Thereafter, a constant differential of 5 psi is maintained. If the cabin pressure regulator should fail, the cabin safety valve automatically limits the differential pressure to 5.5 psi. The CABIN DUMP switch, which is located on a separate control panel in the cockpit, permits either crewmember to manually dump cabin pressure. This switch operates the cabin dump valve, which dumps cabin pressure through the cabin safety valve.

Equipment Cooling Subsystem

The equipment cooling subsystem, which branches off from the pressurization and air-conditioning system and is illustrated in figure

5-2, provides cooling for the aircraft's electronic equipment. Cooling is accomplished by means of ducting ram air to the right forward (shoulder) and aft electronic equipment compartments; by means of moist, cooled bleed air ducted to these same compartments; by means of pressure regulated, temperature controlled bleed air ducted directly to the chassis of the aircraft's ballistics computer set and transmitter modulator; and by means of exhaust air from the computer and the cabin ducted to the chassis of electronic equipment located in the nosewheel well and nose compartment of the aircraft.

Equipment cooling system operation is completely automatic when either or both engines are running and the AIR COND MASTER switch is at NORM.

Ram air is the primary means of ventilation for the forward and aft equipment compartments. When the aircraft is in flight, the equipment cooling valve is closed and the forward and aft electronic equipment compartment ram-air valves are opened, causing these two compartments to be ram air ventilated. If the ambient air temperature becomes excessive (above 136° F), the equipment cooling valve will open and the ram-air valves will close. This permits moist, cooled bleed air to flow into these compartments and insure adequate cooling levels to prevent damage to equipment.

On the later model A-6's, cooled bleed air from the cooling turbine passes through a separate equipment cooling water separator, where 80 to 90 percent of its moisture is removed. This air then passes through a pressure regulator and on to the ballistics computer set. Cooling air to the communications navigation and interrogation (CNI) equipment is supplied from the cabin water separator and is not pressure regulated.

The temperature of the cooled bleed air sent to the ballistics computer set and the transmitter modulator is automatically regulated by the computer temperature control valve, which controls the mixing of hot and cooled bleed air in response to signals sent from computer temperature sensors through the equipment cooling temperature range control box and the defog and equipment cooling controller.

When the computer and the track radar are turned off, bleed air to the computer is maintained at 90° F. If the aircraft is below 21,000 feet altitude and the computer and/or track radar is turned on, the cooling temperature is maintained at 65° F. Above 21,000 feet altitude, the cooling-air temperature is maintained at 40° F.

An overheat safety feature is provided in the computer temperature control valve circuit. If computer duct temperature exceeds 150° F, a thermal switch opens, deenergizing the circuit to the temperature control valve, which closes by internal spring action. This action prevents hot bleed air from flowing and allows uncontrolled cooled bleed air to be ducted to the computer. A caution light on the cockpit annunciator caution light panel indicates to the pilot that an overheat condition exists when duct temperature exceeds 150° F. If the duct temperature drops below 150° F, the caution light will go out. Momentarily placing the CMPTR EMER COOL (computer emergency cooling) switch (fig. 5-1) to the RESET position energizes the circuit between the electrical components and the temperature control valve which opens, and automatic temperature control is resumed.

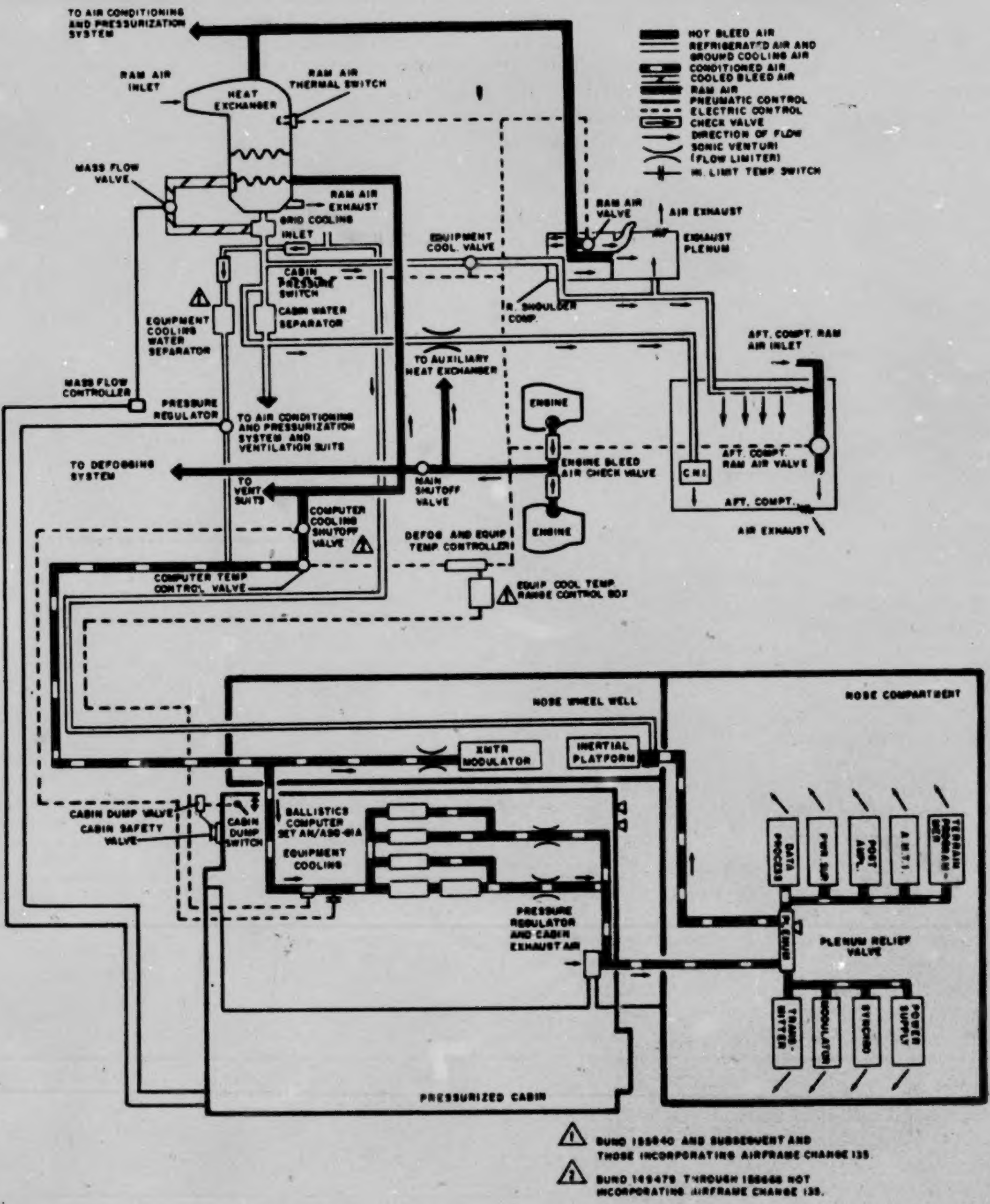
If the computer overheat caution light should cycle on and off, indicating a constant overheat situation, the computer temperature control valve can be permanently closed during the remainder of the flight by placing the CMPTR EMER COOL switch to the ON position. This again allows uncontrolled cooled bleed air to be ducted to the ballistics computer.

Since the inertial platform, located in the nosewheel well compartment, and the electronic equipment, located in the nose compartment, do not need to be held at a fixed temperature, exhaust air from the cabin and the ballistics computer is used to cool this equipment. The exhaust air from these units passes into the nose compartment, then into the nosewheel well compartment and is dumped overboard.

The sonic venturis, located in the computer outlet ducts and the transmitter modulator inlet duct, limit the flow of cooling air through these units.

Equipment Pressurization

Some high-voltage avionics equipment must be pressurized during operation at high altitudes to prevent arc-over. This is caused by the reduced dielectric (capable of sustaining an electrical field) strength of the air as it becomes less dense. The equipment pressurization system up to the point where it connects to the electronic equipment is the responsibility of the


TO AIR CONDITIONING AND PRESSURIZATION SYSTEM
RAM AIR INLET
HEAT EXCHANGER
RAM AIR THERMAL SWITCH
MASS FLOW VALVE
RAM AIR EXHAUST
GRID COOLING INLET
EQUIPMENT COOL. VALVE
CABIN PRESSURE SWITCH
CABIN WATER SEPARATOR
EQUIPMENT COOLING WATER SEPARATOR
R. SHOULDER COMP.
TO AUXILIARY HEAT EXCHANGER
MASS FLOW CONTROLLER
PRESSURE REGULATOR
TO AIR CONDITIONING AND PRESSURIZATION SYSTEM AND VENTILATION SUITS
TO DEFOGGING SYSTEM
TO VENT SUITS
MAIN SHUTOFF VALVE
COMPUTER COOLING SHUTOFF VALVE
DEFOG AND EQUIP TEMP CONTROLLER
ENGINE
ENGINE BLEED AIR CHECK VALVE
ENGINE
COMPUTER TEMP CONTROL VALVE
EQUIP COOL TEMP RANGE CONTROL BOX
HOT BLEED AIR
REFRIGERATED AIR AND GROUND COOLING AIR
CONDITIONED AIR
COOLED BLEED AIR
RAM AIR
PNEUMATIC CONTROL
ELECTRIC CONTROL
CHECK VALVE
DIRECTION OF FLOW
SONIC VENTURI (FLOW LIMITER)
HI. LIMIT TEMP SWITCH
RAM AIR VALVE
AIR EXHAUST
EXHAUST PLENUM
AFT. COMPT. RAM AIR INLET
AFT. COMPT. RAM AIR VALVE
CNI
AFT. COMPT. AIR EXHAUST
NOSE WHEEL WELL
NOSE COMPARTMENT
XMTR MODULATOR
INERTIAL PLATFORM
CABIN DUMP VALVE
CABIN SAFETY VALVE
CABIN DUMP SWITCH
BALLISTICS COMPUTER SET AN/ASQ-61A EQUIPMENT COOLING
PRESSURE REGULATOR AND CABIN EXHAUST AIR
DATA PROCESS
PWR SUP
POST AMPL.
A.M.T.I.
TERRAIN PROGRAMMER
PLENUM
PLENUM RELIEF VALVE
TRANSMITTER
MODULATOR
SYNCHRO
POWER SUPPLY
PRESSURIZED CABIN
1 BUNO 155940 AND SUBSEQUENT AND THOSE INCORPORATING AIRFRAME CHANGE 135.
2 BUNO 149479 THROUGH 155666 NOT INCORPORATING AIRFRAME CHANGE 135.

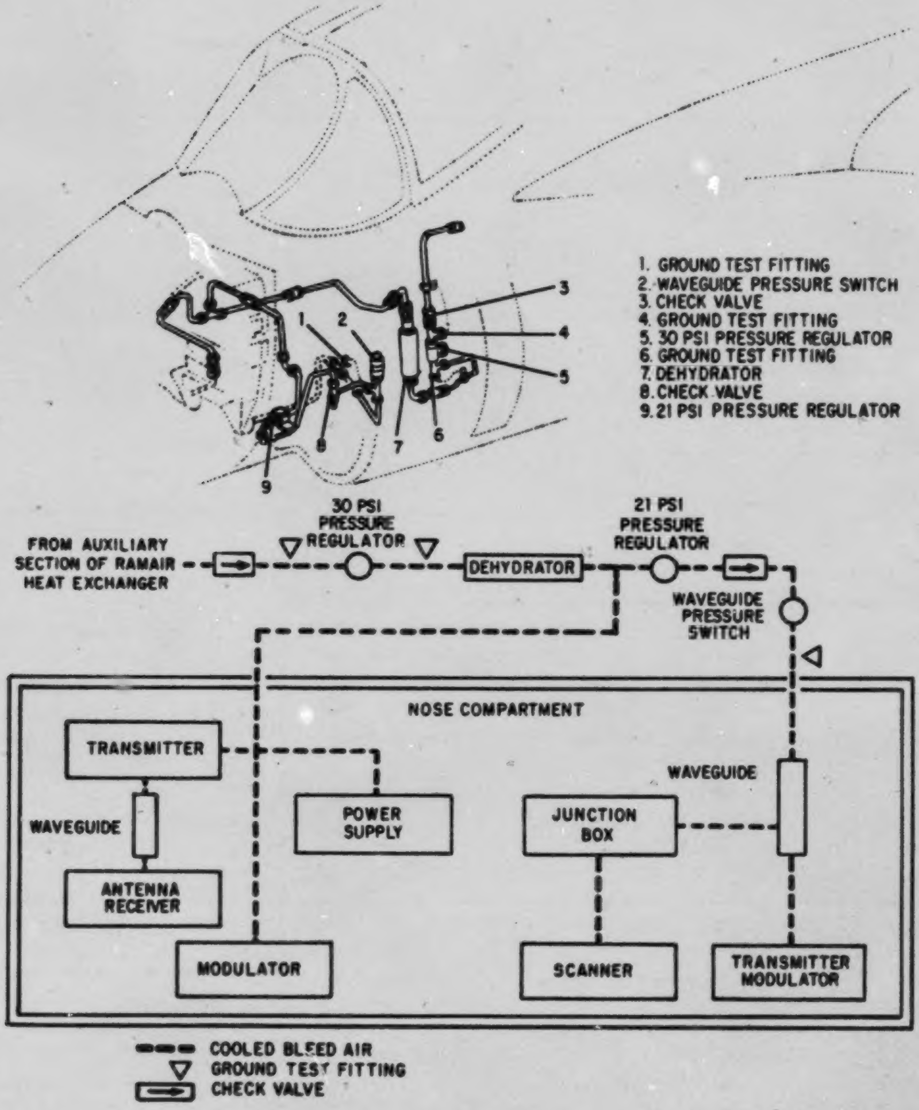
AM.1130

Figure 5-2.—Equipment cooling system (A-6A).

AME. Components or plumbing directly associated with or an integral part of the electronic equipment are the responsibility of the avionics rating (AQ, AT, etc.) that maintains the specific equipment involved.

Figure 5-3 illustrates the equipment pressurization subsystem associated with the air-conditioning and pressurization system discussed previously and illustrated in figure 5-1. Air for the equipment pressurization subsystem is partially cooled air taken from the auxiliary section of the ram-air heat exchanger.

The air first passes through a check valve which prevents reverse flow and isolates the


1. GROUND TEST FITTING
2. WAVEGUIDE PRESSURE SWITCH
3. CHECK VALVE
4. GROUND TEST FITTING
5. 30 PSI PRESSURE REGULATOR
6. GROUND TEST FITTING
7. DEHYDRATOR
8. CHECK VALVE
9. 21 PSI PRESSURE REGULATOR
1
2
3
4
5
6
7
8
9
FROM AUXILIARY SECTION OF RAMAIR HEAT EXCHANGER
30 PSI PRESSURE REGULATOR
DEHYDRATOR
21 PSI PRESSURE REGULATOR
WAVEGUIDE PRESSURE SWITCH
NOSE COMPARTMENT
TRANSMITTER
WAVEGUIDE
ANTENNA RECEIVER
POWER SUPPLY
MODULATOR
WAVEGUIDE
JUNCTION BOX
SCANNER
TRANSMITTER MODULATOR
COOLED BLEED AIR
GROUND TEST FITTING
CHECK VALVE

AM.1131

Figure 5-3.—Equipment pressurization system.

equipment pressurization system when an external air supply is being used during ground functional tests. Air pressure is controlled by a 30-psi and a 21-psi regulator, each controlling pressure to specific equipment. The 30-psi regulator maintains an outlet pressure of 28-32 psi by means of its spring-loaded diaphragm. When pressure reaches the upper limits, the diaphragm moves upward, shutting off the inlet port.

The air used for equipment pressurization must be dry. This is accomplished by using a chemical dehydrator in the line downstream from the 30-psi regulator. The dehydrator uses a molecular sieve desiccant to remove the moisture. A small quantity of silica gel crystals is installed in the dehydrator behind a glass window to provide a visual indication of the dehydrator condition. When the crystals lose their normally deep blue color and change to light blue, the dehydrator must be removed and reactivated. The color change of the crystals is a gradual process and normally starts at the bottom area of the window and gradually spreads over the entire window area. Any variation in the uniformity of the deep blue color is sufficient cause for removal and reactivation of the dehydrator.

NOTE: Reactivation is accomplished by utilizing special support equipment that allows up to 8 dehydrators to be reactivated at one time. Air at approximately 400° F is allowed to flow through the dehydrators under sealed conditions which remove all moisture and return the crystals to their deep blue color. Reactivation generally requires about 3 hours.

Air leaving the dehydrator divides into two branches. Air going to the junction box, scanner, transmitter modulator, and the connecting waveguide passes through the 21-psi regulator which maintains an outlet pressure of 21 ± 2 psi.

NOTE: A waveguide is basically defined as a metal tube or cylinder which transmits electromagnetic waves through its own interior. It guides the direction of such waves and may be filled with air or gas, or evacuated.

The check valve located downstream of the 21-psi regulator prevents pressure loss by reverse flow through the components.

Gage fittings are installed in the system to provide for ground testing of the two regulators. The ground test fitting upstream of the 30-psi regulator is provided for applying an external air supply.

The waveguide pressure switch located downstream of the 21-psi regulator warns of underpressurization of the waveguide and consequent system malfunction. An underpressure condition causes the switch to place the waveguide in a standby (no transmit and receive) condition, thereby preventing avionics system damage.

A description of some of the principal components in a typical system is provided in the following section.

COMPONENTS

Ducting

In most pressurization and air-conditioning installations, two types of ducting are used. High-pressure (stainless steel/titanium) ducting is used from the engine compressor to the refrigeration unit. The remainder is generally low-pressure (aluminum alloy) ducting. Low-pressure ducting is also used in the ram-air lines.

Since bleed-air temperatures may reach as high as 800° F, high-pressure ducting is generally insulated, as shown in figure 5-4. Expansion bellows are also usually incorporated to take care of expansion and contraction of the ducting due to temperature changes.

A check valve is incorporated in this section of the ducting to prevent sudden depressurization of the cockpit should a flame out occur. Figure 5-4 illustrates the correct method of installing one type of check valve.

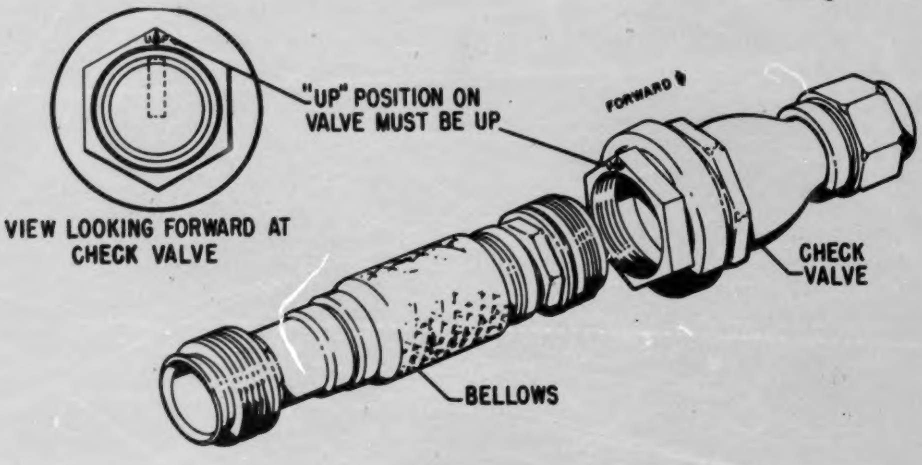
Low-pressure ducting is rarely subjected to pressures greater than 12 psi; however, in some systems a relief valve, set to relieve at 8 to 10 psi, is incorporated.

High-pressure ducting may also be equipped with a relief valve or pressure limiter to control the pressure of air going to the heat exchanger and turbine.

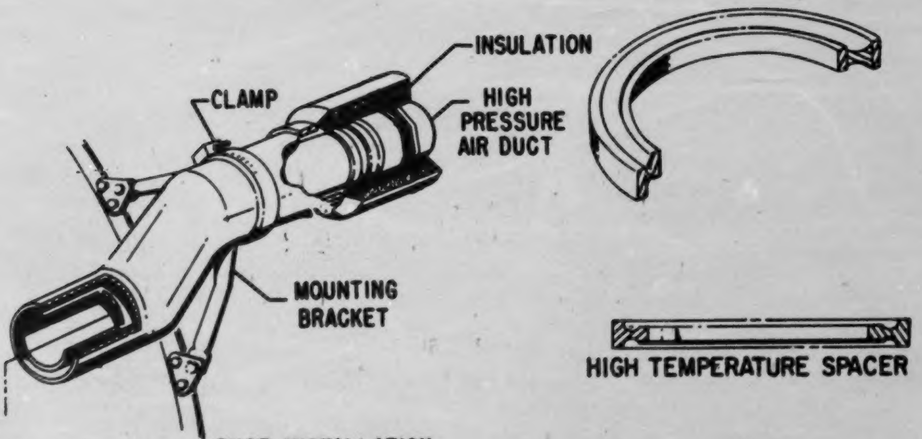
Both low- and high-pressure ducting equipped with flanges utilize some sort of spacer or seal in mating the flanges to each other or to components. Always install the type of seal or spacer specifically called for in the applicable illustrated parts breakdown. The removal and installation procedures in the applicable Maintenance Instructions Manual will also normally list the correct part numbers of consumable items, such as seals and spacers, required in completing a specific maintenance procedure. The seals on the high-pressure connections are generally made of metal (copper or aluminum) to withstand the high temperature of the bleed air. Low-pressure connections generally utilize O-rings.

utoff Valves

Shutoff valves are installed in both the bleed-r ducting and the ram-air ducting. In some in-allations the two valves operate together, being wered by a common motor and actuator. Figure -5 illustrates a dual arrangement shutoff valve. In this arrangement, when the pilot selects ram air, the ram-air section of the valve opens and the bleed-air section closes. When conditioned air is selected, the bleed-air section opens and the ram-air section closes. This type of shutoff valve is generally referred to as a dual-air valve.


"UP" POSITION ON VALVE MUST BE UP
FORWARD
VIEW LOOKING FORWARD AT CHECK VALVE
CHECK VALVE
BELLOWS

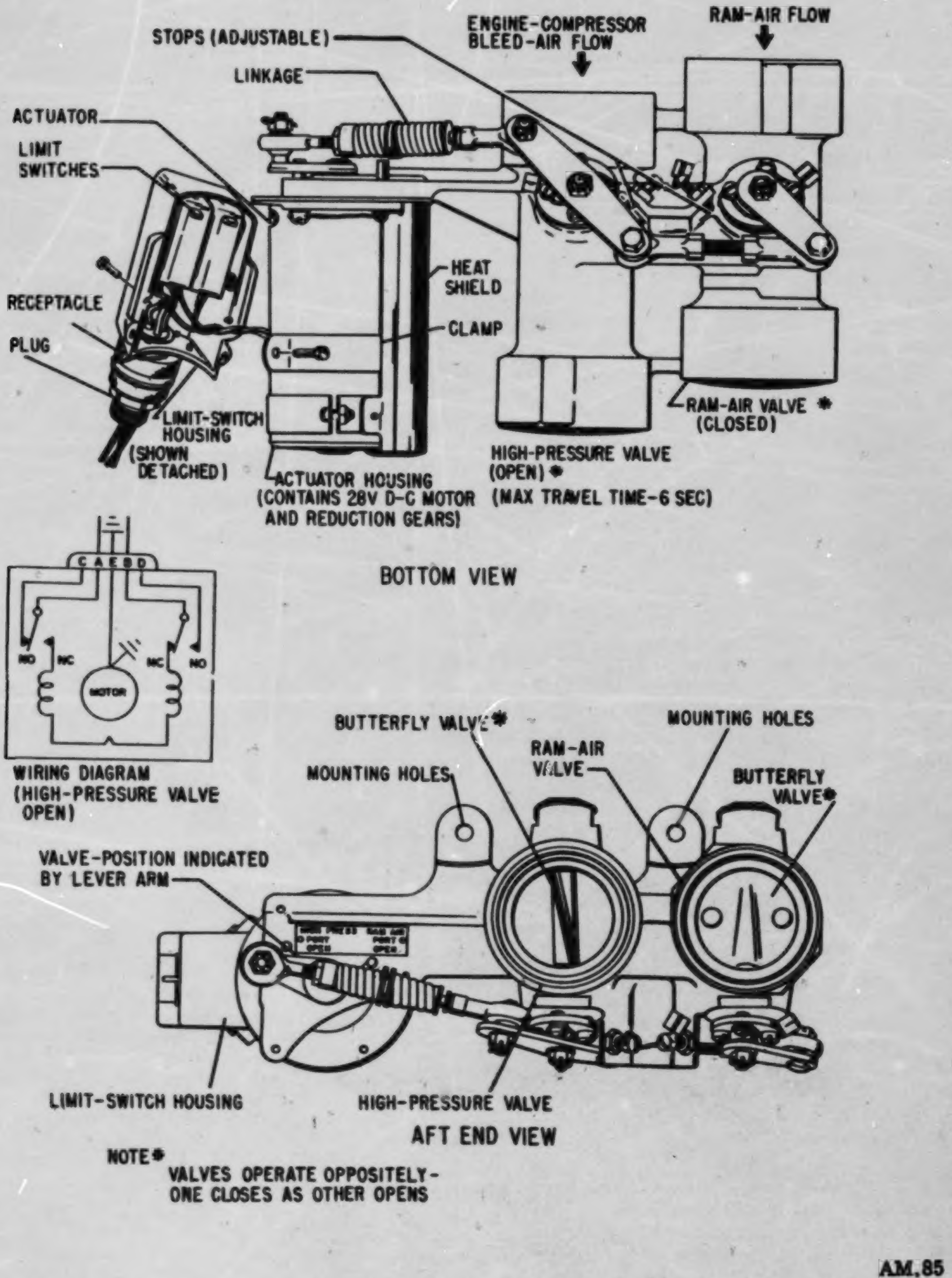
CHECK VALVE INSPECTION


INSULATION
CLAMP
HIGH PRESSURE AIR DUCT
MOUNTING BRACKET
HIGH TEMPERATURE SPACER

DUCT INSTALLATION

AM.84

Figure 5-4.—High-pressure ducting.


STOPS (ADJUSTABLE)
ENGINE-COMPRESSOR BLEED-AIR FLOW
RAM-AIR FLOW
LINKAGE
ACTUATOR
LIMIT SWITCHES
HEAT SHIELD
RECEPTACLE
CLAMP
PLUG
LIMIT-SWITCH HOUSING (SHOWN DETACHED)
RAM-AIR VALVE * (CLOSED)
HIGH-PRESSURE VALVE (OPEN) *
ACTUATOR HOUSING (CONTAINS 28V D-C MOTOR AND REDUCTION GEARS)
(MAX TRAVEL TIME-6 SEC)
BOTTOM VIEW
C A E B D
NO
NC
MOTOR
NC
NO
WIRING DIAGRAM (HIGH-PRESSURE VALVE OPEN)
BUTTERFLY VALVE*
MOUNTING HOLES
RAM-AIR VALVE
MOUNTING HOLES
BUTTERFLY VALVE*
VALVE-POSITION INDICATED BY LEVER ARM
LIMIT-SWITCH HOUSING
HIGH-PRESSURE VALVE
AFT END VIEW
NOTE*
VALVES OPERATE OPPOSITELY-
ONE CLOSES AS OTHER OPENS

AM.85

Figure 5-5.—Shutoff valve (dual-air type).

The valves are made of corrosion resistant steel castings and welded or riveted fabrications to withstand the high bleed-air temperatures encountered.

The cabin bleed-air valve in the system illustrated in figure 5-1 provides an example of a piston type shutoff valve. (See fig. 5-6.) This valve has 1-inch inlet and outlet ports and is a pneumatically operated, solenoid controlled in-line poppet valve. It controls the flow of hot engine bleed air to the dual temperature control valve. The shutoff valve operates in conjunction with the dual-air temperature control valve to shut off cabin air conditioning when the COCKPIT switch (fig. 5-1) is placed at either OFF or RAM AIR.

When the solenoid is energized, the plunger is pulled up, compressing the plunger spring and removing tension from the ball check. The ball is forced into its upper seat by bleed air. The vent from the downstream side of the piston to ambient is sealed, allowing bleed-air pressure to be routed to the backside of the piston. As the combined bleed-air pressure and spring pressure against the piston overtakes the inlet bleed-air pressure, the valve closes.

When the solenoid is deenergized, the plunger spring forces the plunger down, pressing the ball check onto its lower seat. Bleed air to the backside of the piston is blocked and the backside of the piston is again vented to ambient. When the pressure on the backside of the piston has dropped sufficiently, bleed-air forces the piston back against its spring pressure, opening the valve.

The bleed-air shutoff valves are normally designed with some type of heat shielding between the hot air portion and the electrical portion of the valve to protect the electrical components from the high bleed-air temperatures.

Temperature Control Valves

The temperature control valve is a dual type valve similar to the shutoff valve illustrated in figure 5-5. It is an important component in any air-conditioning system. Its function is to mix hot engine bleed air with cooled bleed air for cabin air conditioning.

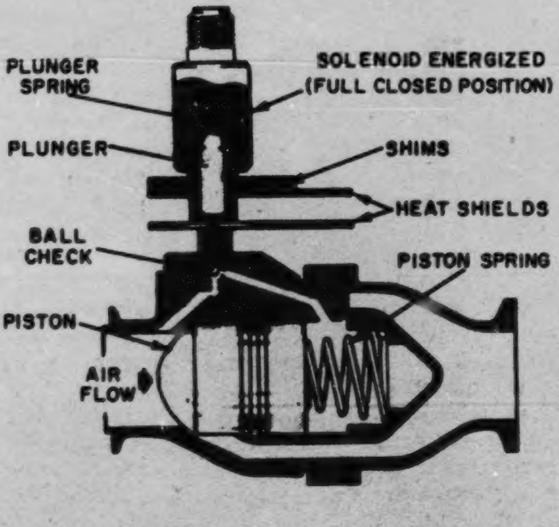
There are two methods by which the temperature control valve receives its information. One method is through the temperature sensors located in the cockpit and in the ducts leading to the cockpit. These thermistors (thermal resistors) change values with temperature changes, thus changing the signal values being sent to the temperature controllers within the system. The controllers constantly reposition the valve to maintain the desired cabin temperature. This method is fully automatic; and once the desired temperature is selected by the pilot, the temperature control valve will be modulated to maintain this condition.

The other method of temperature control is by manual selection. With this method, the pilot actuates the valve manually, through remote controls, to the position he desires.

In some installations, the temperature control valve may be identified by some other name; for example, mixing valve, bypass valve, modulating valve, or proportioning valve. All of these perform basically the same function and operate on a similar principle. Almost all temperature control valves and shutoff valves have position indicators that indicate the relative position of the valve and allow the maintenance man to observe that the valve position corresponds with the actual control settings selected.

Refrigeration Units

Cooling of the hot bleed air is accomplished by a refrigeration unit composed of a main and an auxiliary (air-to-air) heat exchanger, a mass



AM.1132

Figure 5-6.—Cabin bleed-air shutoff valve.

flow control valve, and an air expansion turbine. Cooling of the air may therefore be called a two-phase process.

The first phase of temperature reduction takes place as the hot bleed air passes through the thin-walled tubing of the main and auxiliary heat exchangers. Coolant (ram) air is drawn around these tubes by the turbine-driven axial-flow fan. The heat exchangers use common inlet and outlet ducts for cooling air.

The design and the construction of the heat exchanger are such that a substantial portion of the heat is transferred through the tubing walls to the coolant air as it is drawn through the heat exchangers. Figure 5-7 illustrates the flow of engine bleed air and coolant (ram) air through the heat exchangers. The heated coolant air is dumped overboard. Partially cooled air from the auxiliary heat exchanger is ducted to the windshield washing and equipment pressurization subsystems.

Part of the partially cooled bleed air from the main heat exchanger is sent to the defogging subsystem. The remaining partially cooled air is directed through the mass flow control valve to the cooling turbine for further cooling by the extraction of work. The cooling turbine is turned by the force of the partially cooled air impinging on the turbine blades. The energy imparted to the turbine wheel is absorbed by the coolant or ram-air intake fan, which is mounted on the same shaft as the turbine. The turbine turns at a high rate of speed, and air passing through the curved blades of the turbine wheel is expanded with a resultant pressure drop slightly above the pressure in the cockpit. The energy used in turning the turbine wheel drops the temperature as well as pressure of the air to design requirements. This cooled, slightly pressurized air is then directed through the turbine outlet and into environmental control system ducting.

Mass Flow Control Valve

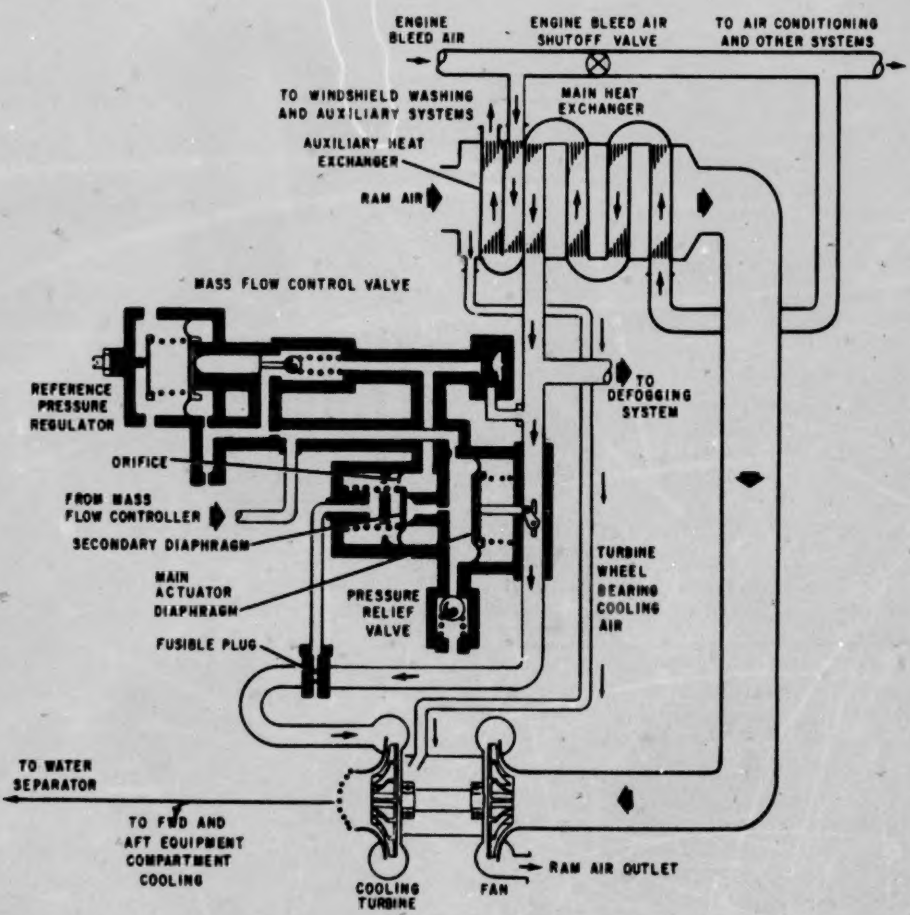
The mass flow control valve regulates the mass (volume) of air flowing to the turbine in response to a pneumatic signal from the mass flow controller. The valve modulates to aid the dual temperature control valve in controlling cabin temperature. As the signal entering the reference regulator (fig. 5-7) increases, pressure above the main actuator diaphragm also rises and the mass flow control valve begins to close. This reduces the flow to the turbine and consequently flow to the environmental control system. Pneumatic inlet pressure also flows to one side of the secondary diaphragm and through an orifice to the other side of the diaphragm. If the temperature of the air flowing to the turbine reaches a predetermined high limit, the fusible plug (fig. 5-7) melts and vents the rear side of the secondary diaphragm to the atmosphere. The secondary diaphragm lifts off its seat and inlet pressure acting on the main actuator diaphragm closes the valve. The chamber behind the main actuator diaphragm is protected from overpressurization by a relief valve that discharges overpressure to atmosphere.

The manner in which the valve operates is illustrated by the following typical sequence: Assume that the cabin temperature is stabilized and that the dual temperature control valve is in the full cold position (cold butterfly open, hot butterfly closed). As the aircraft changes altitude, the cabin temperature decreases and the cold butterfly starts to close. The increased pressure caused upstream of the temperature control valve is sensed by the mass flow controller, which sends a pneumatic signal to the mass flow control valve, driving it toward the closed position. The turbine discharge flow decreases and temperature rises slightly. The result at the cold butterfly of the temperature control valve is a decreased flow of cool air at a slightly increased temperature, which will aid in the restabilization of the cabin temperature.

Cockpit Air Outlets

The cockpit air is distributed by tubes which on most aircraft run lengthwise on each side of the pilot and contain a large number of small holes from which air is directed. One set of tubing is generally routed to permit discharge of air at the pilot's feet and another set of tubing directs air to the legs and other body areas. On most installations, several types of diffusers provide proper distribution of air. Foot diffusers normally consist of butterfly type valves which are manually operated. Cabin air diffusers on larger aircraft normally are louvered discs that can be rotated 360° to direct air in any direction as needed. Most are equipped so that air can be shut off if desired when the air-conditioning system is operating.

Face diffusers are normally eyeball type socket devices that may be rotated 30° about the neutral position by manually moving the outlet in its socket. Airflow is initiated by pulling


ENGINE BLEED AIR
ENGINE BLEED AIR SHUTOFF VALVE
TO AIR CONDITIONING AND OTHER SYSTEMS
TO WINDSHIELD WASHING AND AUXILIARY SYSTEMS
MAIN HEAT EXCHANGER
AUXILIARY HEAT EXCHANGER
RAM AIR
MASS FLOW CONTROL VALVE
REFERENCE PRESSURE REGULATOR
TO DEFOGGING SYSTEM
ORIFICE
FROM MASS FLOW CONTROLLER
SECONDARY DIAPHRAGM
TURBINE WHEEL BEARING COOLING AIR
MAIN ACTUATOR DIAPHRAGM
PRESSURE RELIEF VALVE
FUSIBLE PLUG
TO WATER SEPARATOR
TO FWD AND AFT EQUIPMENT COMPARTMENT COOLING
COOLING TURBINE
FAN
RAM AIR OUTLET

AM.1133

Figure 5-7.—Air cycle refrigeration unit.

outward on the lip of the outlet or turning it counterclockwise.

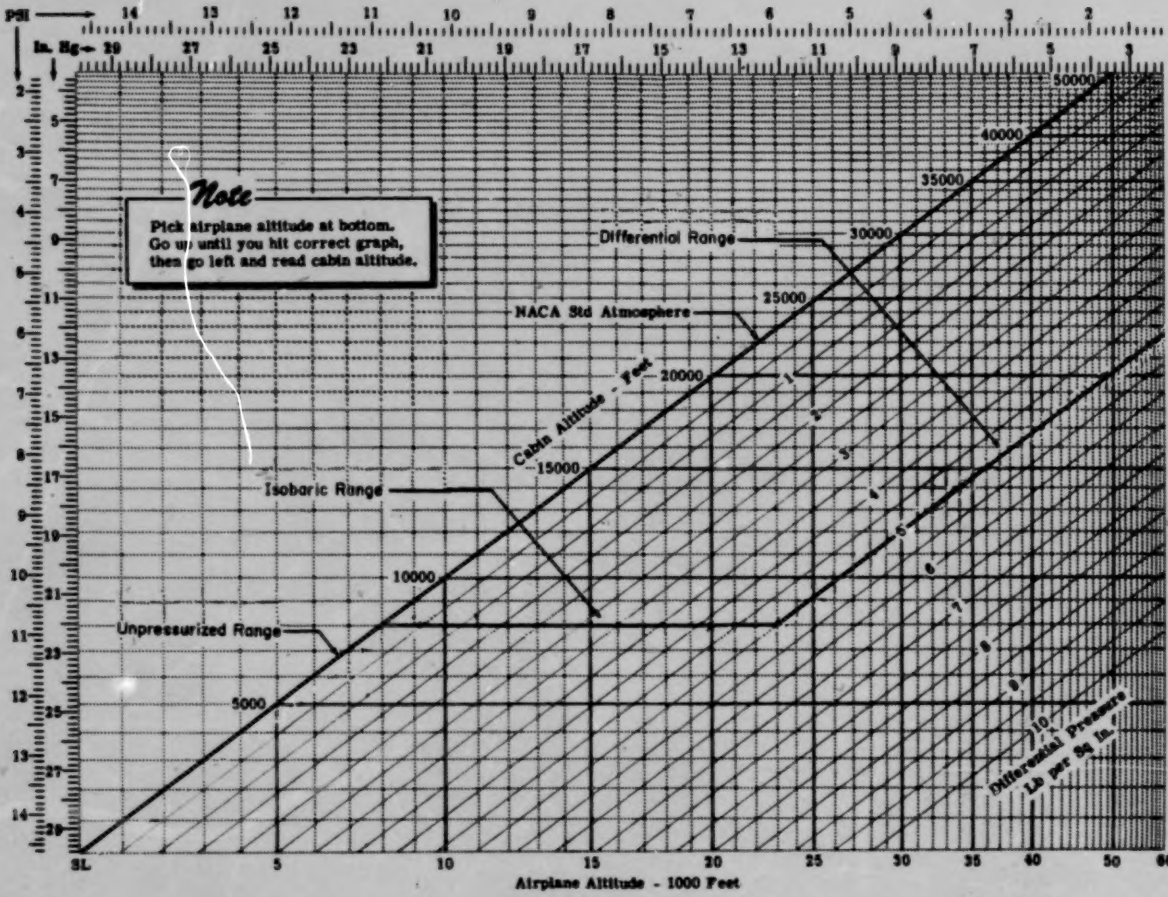
Pressure Regulators

The pressure regulator of an air-conditioning and pressurization system is designed to regulate the outflow of air from the cockpit or cabin, thereby maintaining cabin pressure at a desired pressure altitude.

The operation of a typical pressure regulator may be considered in three ranges—the unpressurized range, the isobaric range, and the differential range. Figure 5-8 is a typical cabin pressure chart, showing these three ranges of operation.

The UNPRESSURIZED RANGE may be defined as the altitude range over which the cabin pressure remains approximately equal to atmospheric pressure. In the typical pressure schedule shown, this range extends from sea level to 8,000 feet. For some aircraft, the unpressurized range extends to only 5,000 feet, on some others to 10,000 feet.

The ISOBARIC RANGE may be defined as the altitude range over which the cabin remains at a constant pressure altitude. For example, in the schedule shown in figure 5-8, cabin pressure



AM.87

Figure 5-8.—Typical cabin pressure chart.

remains constant from 8,000 feet altitude to 23,000 feet altitude. In other words, during this range, cabin pressure remains equivalent to atmospheric pressure at the 8,000-foot level.

The DIFFERENTIAL RANGE may be defined as the altitude range over which a constant difference between cabin pressure and atmospheric pressure is maintained. In the schedule shown in figure 5-8, a differential of 5 psi is maintained from 23,000 feet altitude to the maximum altitude of the aircraft. As an example, assume that the aircraft is flying at an altitude of 35,000 feet. Outside atmospheric pressure at this altitude is 3.5 psi and cabin pressure is 8.5 psi, a differential of 5 psi. Now assume that the aircraft climbs to an altitude of 40,000 feet. Outside atmospheric pressure at this altitude is 2.8 psi, and cabin pressure is 7.8 psi, the differential remaining at 5 psi.

OPERATION.—A typical pressure regulator is shown in figure 5-9. The regulator consists of two sections—the head and reference chamber (control chamber) and the outflow valve and diaphragm section. The regulator is automatically controlled by utilizing air from the cabin. Cabin air enters the reference chamber through the air orifice and filter to establish a reference pressure. The balance chamber between the outflow valve and the balance diaphragm pneumatically balances the outflow valve, thus the outflow valve will open or close as reference pressure increases or decreases through the various modes of operation.

Unpressurized Operation.—Figure 5-10 (A) shows the pressure regulator in unpressurized operation. During this range of operation, reference-chamber pressure is sufficient to allow the evacuated isobaric bellows to remain contracted, thus holding the isobaric needle valve in the open position. Cabin air is bled into the reference chamber through the filter and orifice and flows out through the open needle valve and vent line to atmosphere. Since the filter orifice is smaller than the isobaric needle valve vent, pressure in the reference chamber is less than cabin pressure. This causes the actuator diaphragm to move toward the low-pressure side, opening the outflow valve and allowing the cabin air to flow to atmosphere until the pressure differential between the cabin and atmosphere approaches zero.

Isobaric Operation.—Isobaric operation of the pressure regulator is shown in figure 5-10 (B). As the isobaric altitude is approached, the pressure in the reference chamber decreases. This results in the evacuated isobaric bellows expanding and moving the needled valve towards its seat. The expansion of the isobaric bellows is aided by the tension of the isobaric calibrating spring. The needle valve moving towards its seat tends to close off the vent from the reference chamber to atmosphere. This action of the needle valve prevents further decrease in reference-chamber pressure and maintains the chamber at a substantially constant pressure throughout the isobaric range of operation. Since reference-chamber pressure is held at a constant value, any decrease in cabin pressure, as the aircraft ascends, results in a movement of the actuator diaphragm toward the low-pressure side. This moves the outflow valve toward the closed position, restricting the flow of cabin air to atmosphere until cabin pressure is stabilized at the calibrated constant isobaric value.

Differential Operation.—As the aircraft ascends to the upper limits of altitude at which the regulator is calibrated to maintain isobaric control, the differential pressure between the cabin and atmosphere approaches the maximum calibrated value. Also, the differential pressure between the reference chamber and atmosphere becomes great enough to result in the differential diaphragm moving and opening the differential needle valve. As the aircraft continues to ascend, the opening of the differential needle valve takes over control from the isobaric needle valve which is now virtually closed (fig. 5-10 (C)). Since action of the differential diaphragm is a result of the differential pressure between the reference chamber and atmosphere, the positioning of the needle valve holds this differential constant and consequently maintains a constant differential pressure between the aircraft cabin and atmosphere.

REMOVAL AND INSTALLATION.—The pressure regulator must be replaced if it is found to be defective during troubleshooting. The specific Maintenance Instructions Manual should be consulted before replacing the regulator. The following steps will aid in its removal:

1. Turn off aircraft electrical power.
2. Remove access panels from the wing.
3. Disconnect bleed-air line, pressure sensing line, and pressure manifold from valve.
4. Remove bolts, nuts, and washers that secure valve to bracket assembly and remove valve.

Reverse the steps when installing the new regulator. After the regulator has been installed, an operational check must be made.

Cabin Air Pressure Safety Valve

The purpose of the air safety valve is threefold. It acts as an automatic pressure relief valve in case cabin pressure exceeds the established limits. It acts as an automatic vacuum relief valve in case cabin pressure becomes less than atmospheric pressure. It serves as a means of dumping cabin pressure in the event depressurization is desired.

The safety valve used on most pressurized aircraft is similar to the one shown in figure 5-11. The valve is a normally closed, pneumatically operated and controlled, fully automatic unit that can be electrically activated to the dump position. NOTE: The dump feature in some safety valves may be manual.

OPERATION.—Most cabin air pressure safety valves operate in a manner similar to the following. NOTE: The pressures may vary slightly in some cases.

Pressure relief occurs when the cabin pressure is allowed to exceed atmospheric pressure by 5.4 psi. At this point, cabin pressure overcomes the combined forces of atmospheric

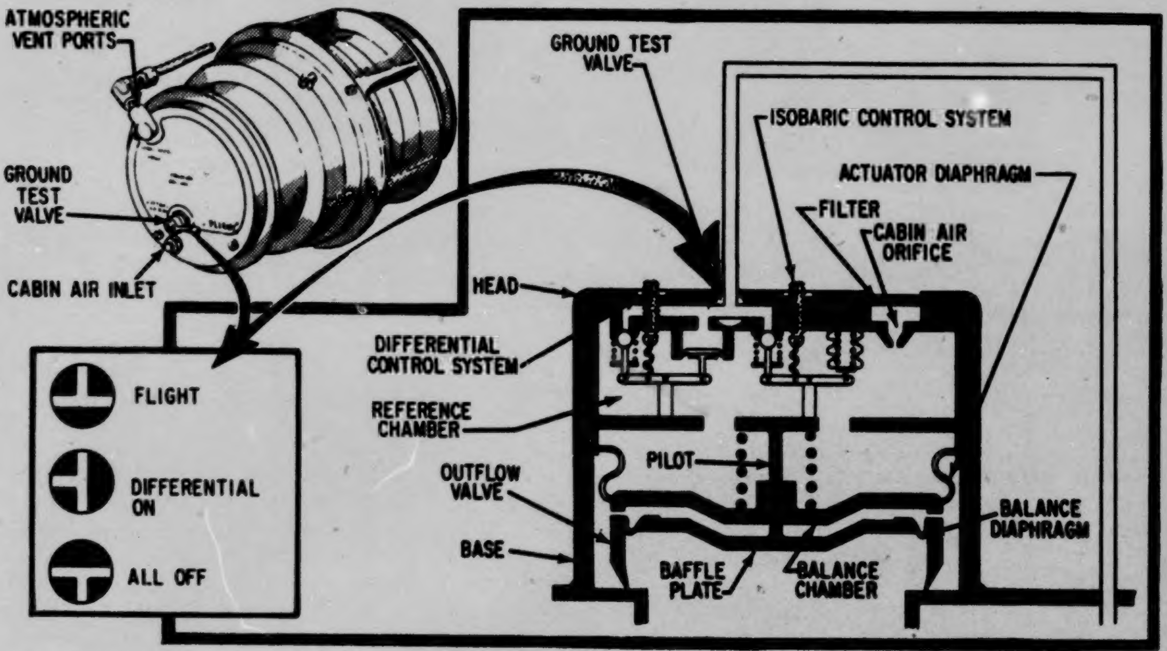

ATMOSPHERIC VENT PORTS
GROUND TEST VALVE
CABIN AIR INLET
GROUND TEST VALVE
ISOBARIC CONTROL SYSTEM
ACTUATOR DIAPHRAGM
FILTER
CABIN AIR ORIFICE
HEAD
DIFFERENTIAL CONTROL SYSTEM
REFERENCE CHAMBER
PILOT
OUTFLOW VALVE
BASE
BAFFLE PLATE
BALANCE CHAMBER
BALANCE DIAPHRAGM
FLIGHT
DIFFERENTIAL ON
ALL OFF
AM.88

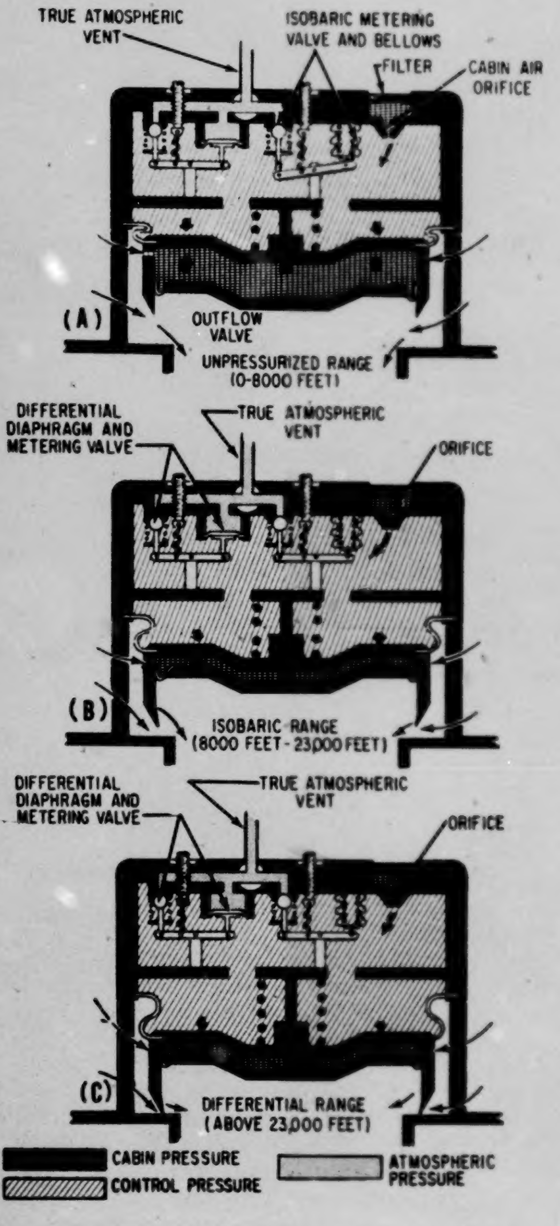
Figure 5-9.—Cabin pressure regulator.

pressure and spring tension in the control chamber, moving the metering valve back against the calibration screw. When forced against the calibration screw, the metering valve opens, allowing reference-chamber air to escape through the outer compartment to atmosphere. As air is drained from the reference chamber, the force of cabin pressure against the outflow valve overcomes spring tension and moves it to the open position, allowing cabin air to flow to atmosphere. The rate-of-flow of cabin air to atmosphere is determined by the amount the cabin-to-atmosphere pressure differential has been allowed to exceed the 5.4 psi calibration point. As cabin pressure is reduced to below 5.4 psi, the forces opening the valve will be proportionately reduced, allowing it to return to the normally closed position.

Vacuum relief occurs when atmospheric pressure exceeds cabin pressure by 0.25 psi. At this point, the force of atmospheric pressure against the external surface of the outflow valve causes the valve to open and allows air to flow into the cabin.

In addition to the automatic operating provisions just described, the valve includes provisions for electrical activation to the dump position. This is accomplished by a passage in the head that allows reference-chamber air to vent directly to atmosphere. The flow of air through the passage is controlled by a ball check valve and an air solenoid valve. The solenoid valve is spring loaded to a normally closed position. When the solenoid valve is opened by positioning the cockpit pressure switch to RAM EMER, air flows from the reference chamber, decreasing the reference pressure and allowing the outflow valve to open and dump cabin air.

Manual dumping of cabin pressure in the typical air-conditioning and pressurization system (fig. 5-1) is accomplished in a similar


TRUE ATMOSPHERIC VENT
ISOBARIC METERING VALVE AND BELLOWS
FILTER
CABIN AIR ORIFICE
(A)
OUTFLOW VALVE
UNPRESSURIZED RANGE (0-8000 FEET)
DIFFERENTIAL DIAPHRAGM AND METERING VALVE
TRUE ATMOSPHERIC VENT
ORIFICE
(B)
ISOBARIC RANGE (8000 FEET-23,000 FEET)
DIFFERENTIAL DIAPHRAGM AND METERING VALVE
TRUE ATMOSPHERIC VENT
ORIFICE
(C)
DIFFERENTIAL RANGE (ABOVE 23,000 FEET)
CABIN PRESSURE
CONTROL PRESSURE
ATMOSPHERIC PRESSURE

AM.89

Figure 5-10.—Pressure regulator operation.

manner except that the solenoid-operated dump valve is not an integral part of the cabin safety valve. A line from the reference chamber connects to the inlet of a separate dump valve which is normally at the closed position. Placing the cabin dump switch to ON vents the reference chamber through the dump valve, and cabin pressure is able to unseat the cabin safety valve and dump overboard in much the same manner as illustrated in figure 5-11.

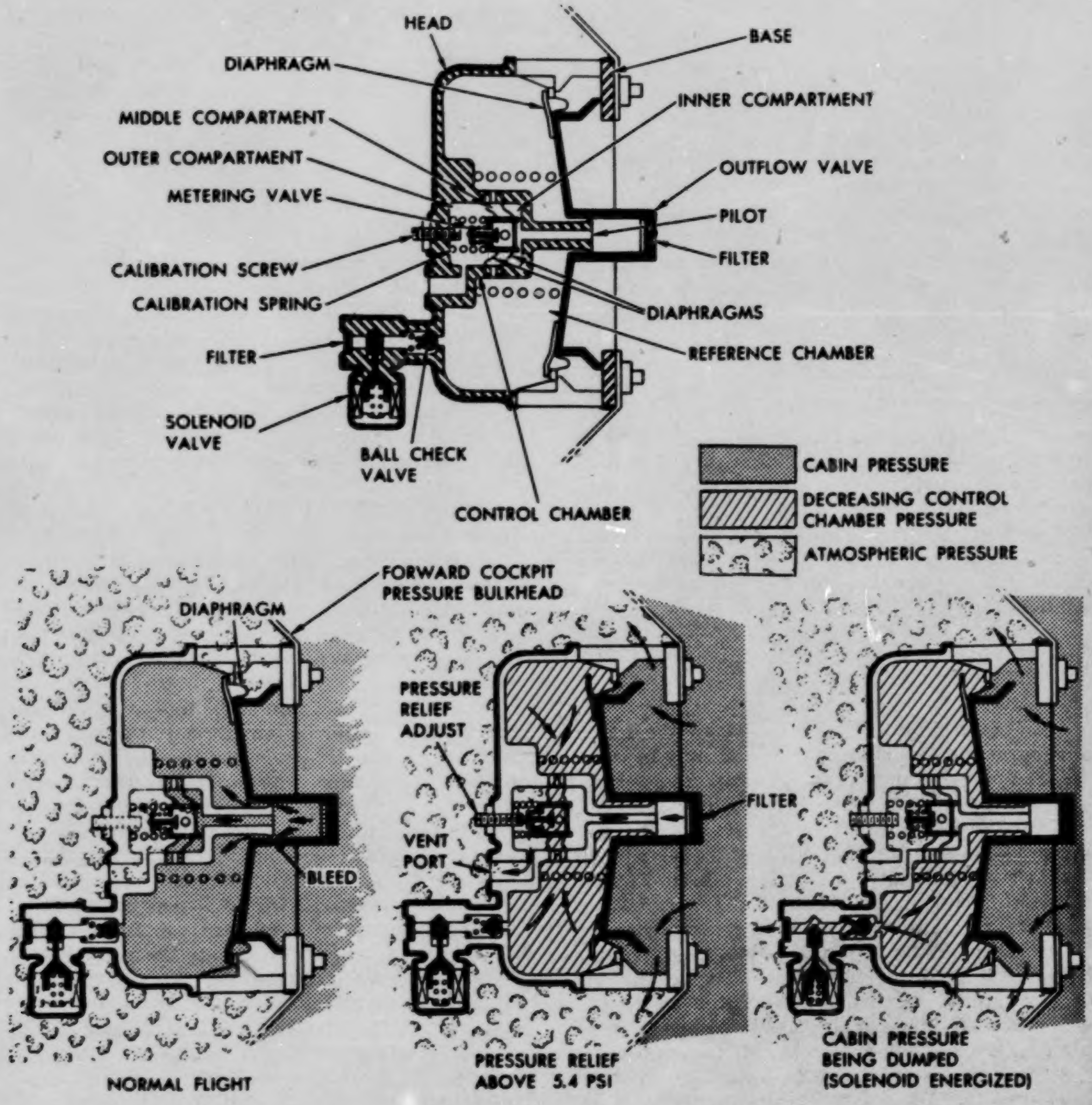
Water Separators

Water separators in both the cabin and equipment cooling systems provide necessary humidity control for cooled air entering the cabin and electronic equipment. Figure 5-12 illustrates the two types of water separators utilized in the typical air-conditioning and pressurization systems (figs. 5-1 and 5-2).

The cabin water separator removes entrained water from the refrigerated air discharging from the cooling turbine of the air cycle refrigeration unit. The separator removes water particles by combining small water particles in the air, then separating the larger, heavier particles from the airstream by centrifugal force. Air enters the separator, passes through a fiber glass condenser, and is swirled as it passes through the closely spaced swirl vanes of the condenser support. The water particles in the swirling air, being heavier, are thrown outward against the walls of the collector. The collector is a perforated cylindrical shell that divides the outlet shell into inner and outer chambers. The water droplets pass through the collector to the inactive outer chamber, collect in the sump, and then drain overboard through the drain boss on the bottom of the sump.

If foreign material clogs the condenser, the decreased airflow through the condenser will cause a differential pressure across the bypass valve, which is located in the inlet of the condenser support. When the differential pressure exceeds the force of the bypass valve load spring, the valve opens and air passes through the valve instead of the condenser. This bypassing action insures a flow of air to the cabin, ventilation suits, and electronic equipment. Lack of proper cooling would be more detrimental than the introduction of cool, humid air.

The equipment cooling water separator works in a similar manner. As air enters the inlet of the separator, it passes through a two-stage coalescer which merges entrained moisture into large water droplets. The air then passes through the swirling vanes (blade) and the centrifugal


HEAD
BASE
DIAPHRAGM
INNER COMPARTMENT
MIDDLE COMPARTMENT
OUTER COMPARTMENT
OUTFLOW VALVE
METERING VALVE
PILOT
CALIBRATION SCREW
FILTER
CALIBRATION SPRING
DIAPHRAGMS
FILTER
REFERENCE CHAMBER
SOLENOID VALVE
BALL CHECK VALVE
CONTROL CHAMBER
CABIN PRESSURE
DECREASING CONTROL CHAMBER PRESSURE
ATMOSPHERIC PRESSURE
FORWARD COCKPIT PRESSURE BULKHEAD
DIAPHRAGM
PRESSURE RELIEF ADJUST
FILTER
VENT PORT
BLEED
NORMAL FLIGHT
PRESSURE RELIEF ABOVE 5.4 PSI
CABIN PRESSURE BEING DUMPED (SOLENOID ENERGIZED)

AM.90

Figure 5-11.—Cabin air pressure safety valve.

force of the air being swirled throws the water droplets against the collector. Water passes through the collector, into the absorber cartridge, and ultimately out the drain boss.

An air bypass is provided in the coalescer assembly to permit cooling-air flow through the separator in the event the coalescers become clogged with foreign matter.

MAINTENANCE AND INSPECTION

Very little maintenance is required on most pressurization and air-conditioning systems other than making the required periodic inspections and operational checks. Many of the components are repairable at the Depot level of maintenance rather than at lower levels of maintenance because of the high cost of special equipment required for making adjustments necessary to proper operation.

In most instances, a maladjusted or malfunctioning component must simply be removed and replaced. There are, however, certain components which require periodic servicing, cleaning, and inspection so that the component will function properly and efficiently and may be considered reliable for flight. The maintenance considerations and requirements discussed in this section are general in nature and should be performed as applicable. Specific requirements are listed in the daily, postflight, special/conditional, and calendar Maintenance Requirements Card (MRC) decks as well as the Maintenance Instructions Manual for each aircraft as applicable.

Pressure Regulators

Close attention should be given the cabin pressure regulator since this unit may be considered the "brain" of the pressurization system. Some Maintenance Instructions Manuals and MRC's indicate that the internal filter found in most pressure regulators be removed and cleaned periodically. A solvent such as trichloroethylene is recommended for removing any foreign matter which has accumulated in the filter. The filter should be allowed to dry thoroughly before reinstalling. On some types of regulators, removal of the filter would require partial disassembly, which may be prohibited. Consult the applicable MIM in each case.

The outflow-valve faces must be cleaned periodically. Since all cabin air must flow through the outflow valve, nicotine tars and other foreign particles will accumulate on the valve faces. This may cause the valve to stick in the closed position. Both faces of the valve should be wiped clean with a clean soft cloth saturated with solvent. In most cases the regulator will have to be removed from the aircraft to accommodate cleaning.

Safety Valves

The filter and valve faces of the cabin safety valve should be cleaned in the same manner as those for the pressure regulator when applicable. The bleed orifice (fig. 5-11) should be cleaned periodically by carefully inserting a length of "tag wire" into the bleed hole and running it back and forth through the orifice.

Shutoff and Temperature Control Valves

Shutoff and temperature control valves in the pressurization and air-conditioning system should be checked for binding of the butterfly (or gate) and for loose, bent, binding, or broken linkage. All valves should be checked for security of mounting and for loose connections.

Any appreciable leakage through a shutoff valve is an indication that the valve should be investigated and that corrective action may be necessary.

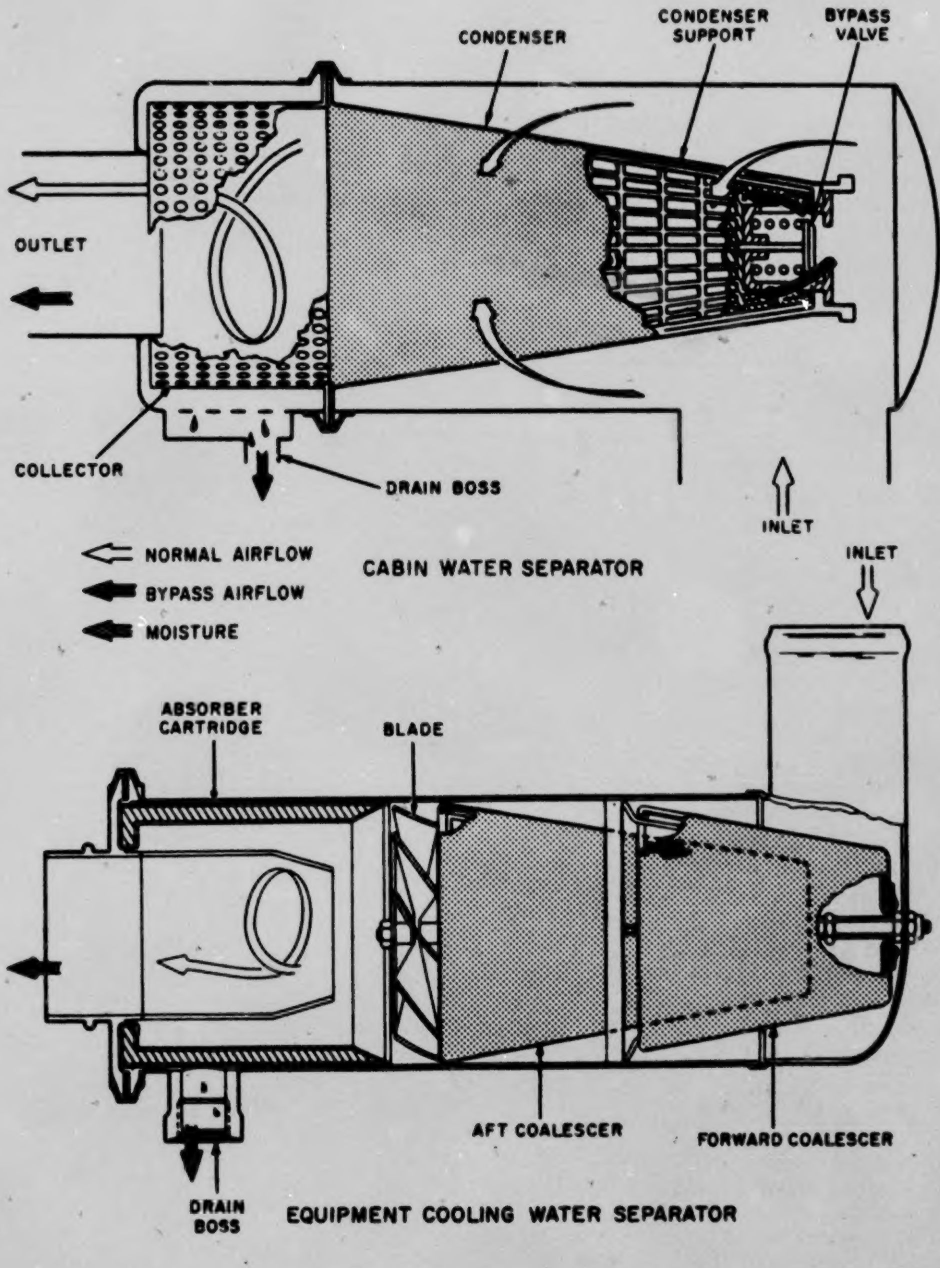
The travel limits of a shutoff valve actuator should be checked at the first indication of malfunctioning. When valve malfunction is suspected, the travel sequence should be checked to determine if the valve is fully closed when the cockpit control is placed in the OFF position and fully open when the control is in the the ON position.

The relative position of the temperature control valves should be monitored in manual and automatic modes of operation by observing their position indicators as various temperature ranges are selected. Failure of the valve to work in the automatic mode may be due to temperature controller malfunctioning rather than an inoperative valve. Operation of the valve in the manual mode will verify proper operation of the drive motor and gear train and freedom of the butterfly valve to change position, thus isolate the trouble to the temperature controller and associated temperature sensors.

It should be remembered that actuators and other electrically actuated components are the responsibility of the electric shop; however, these units may be checked for broken, loose, or frayed electrical leads and security of mounting by a qualified AME. The importance of the AME and AE working together cannot be overstressed.

Refrigeration Units

The Maintenance Requirements Cards for some aircraft require periodic inspection of the


CONDENSER
CONDENSER SUPPORT
BYPASS VALVE
OUTLET
COLLECTOR
DRAIN BOSS
INLET
NORMAL AIRFLOW
BYPASS AIRFLOW
MOISTURE
CABIN WATER SEPARATOR
INLET
ABSORBER CARTRIDGE
BLADE
AFT COALESCER
FORWARD COALESCER
DRAIN BOSS
EQUIPMENT COOLING WATER SEPARATOR

AM.1134

Figure 5-12.—Water separators.

refrigeration unit for fatigue cracks, corrosion, dents, and the general integrity of the complete unit. Any damage that could result in failure or malfunction of the unit is cause for removal.

CAUTION: When removing most refrigeration units, it is important to keep the unit in the upright position to prevent internal oil leakage.

Always cap or cover all openings in the system and the unit itself during removal and installation. Cleanliness is of the utmost importance. Foreign particles will cause damage to moving parts of the refrigeration unit or valves to malfunction. The turbine turns at a very high rpm and damage to the vanes could cause it to fail and possibly fly apart.

On some aircraft, periodic lubrication of the turbine(s) is required and the heat exchanger cores must be cleaned. Lubrication should be in strict accordance with the instructions contained in the aircraft Maintenance Instructions Manual and/or Maintenance Requirements Cards. On some turbines the oil level in the reservoir is checked with a dipstick. Never fill the reservoir above the recommended level. Insure that the dipstick is clean prior to checking the oil level.

In checking the oil for contamination, use a clean syringe, drawing a sample of oil from the bottom of the reservoir or sump. Deposit the oil sample in a clean glass container and allow it to settle. If any contamination such as water, foreign particles, or unknown substance becomes apparent, drain and refill the reservoir. Lubricating oil conforming to Military Specification MIL-L-6085A is recommended by most turbine manufacturers.

Lubrication of the turbine utilized in the typical air-conditioning and refrigeration system (figs. 5-1 and 5-7) is performed in the following manner:

Remove the drain plug and allow any condensation in the sump to drain out. Reinstall the drain plug.

Remove the fill plug and fill the turbine sump with not more than 180 cc of oil.

Allow 15-20 minutes for the oil to distribute properly in the sump.

Remove the drain plug and drain the oil.

NOTE: Cotton packing in the turbine assembly will retain the proper amount of oil for lubrication. Approximately 20 minutes is required to properly drain off the excessive oil. Inserting a clean piece of wire approximately 1/2 inch into the cotton in the sump will facilitate drainage.

Install drain and fill plugs with gaskets and lockwire.

The air-conditioning turbine is lubricated every 375 flight hours and is removed for high time overhaul when it has operated 750 flight hours. A Scheduled Removal Component Card (SRC), OpNav 4790/28A, which provides a complete history of the turbine must accompany the part when it is turned in to material control for ultimate shipment to the overhaul activity. Intermediate level maintenance of the complete refrigeration unit is restricted to replacement of miscellaneous parts listed in Spares and Repair Parts Data found in section IV of the applicable MIM.

Water Separator

Maintenance of the water separators illustrated in figure 5-12 includes replacement of miscellaneous parts and periodic cleaning, both of which can be accomplished at the Organizational maintenance level.

Cleaning requires disassembly and cleaning of metal parts with drycleaning solvent. If the condenser or coalescers and absorber cartridge are not defective, they may be cleaned using a mild soap solution, rinsed, and dried with low-pressure compressed air.

If the water separator is removed from service for suspected malfunction, it is subjected to a pressure leakage test and may be repaired to a greater depth at the Intermediate level of maintenance, utilizing the same Field Parts Kit that was available to the Organizational level maintenance activity plus other parts of the water separator available as individual items.

System Ducting

A leak in the ducting can prevent or reduce cockpit pressurization and can overwork the refrigeration unit. Leaks in the low-pressure ducting can reduce airflow to the defrosting system and thus cause impaired visibility. Leakage in the ram-air ducting and ram-air valve can seriously hamper proper operation of the refrigerating system. Any leak will result in a loss in efficiency and should be repaired promptly. WARNING: A LEAK IN HIGH-PRESSURE DUCTING CAN RESULT IN FIRE OR IN FAILURE OF STRESSED ALUMINUM STRUCTURE AGAINST WHICH LEAKING AIR IS DIRECTED.

A variety of clamping devices are utilized in connecting aircraft environmental control system ducting sections to each other or to various components. Whenever lines, components, or ducting are disconnected or removed for any reason, install suitable plugs, caps, or coverings on the openings to prevent the entry of foreign materials. Tag the various parts to insure correct reinstallation. Care should be exercised during handling and installation to insure that flanges are not scratched, distorted, or deformed. Flange surfaces should be free of dirt, grease, and corrosion. The protective flange caps should be left on the ends of the ducting until the installation progresses to the point where removal is necessary to continue with the installation.

In most cases it is mandatory to discard and replace seals and gaskets. Insure that seals and gaskets are properly seated and that mating and alignment of flanges are fitted so that excessive torque is not required to close the joint and impose structural loads on the clamping device. Adjacent support clamps and brackets should remain loose until installation of the coupling has been completed.

Marman type clamps commonly used in ducting systems should be tightened to the torque value indicated on the coupling. Tighten all couplings in the manner and to the torque value as specified on the clamp or in the applicable Maintenance Instructions Manual.

INSTALLING CHECK VALVES.— When installing check valves in the system ducting, always install the valve with the arrow pointing in the direction of airflow; and the word "UP" printed on the valve in the up position.

INSTALLING FLEXIBLE CONNECTORS/COUPLINGS.—Some of the most commonly used plain band couplings are illustrated in figure 5-13. When installing a hose between two duct sections, as illustrated in figure 5-13, the gap between the duct ends should be 1/8 inch minimum to 3/4 inch maximum. When installing the clamps on the connection, the clamp should be 1/4 inch minimum from the end of the connector. Misalignment between the ducting ends should not exceed 1/8 inch maximum.

When installing flexible couplings, such as the one illustrated in figure 5-14, the following steps are commended to assure proper security:

1. Fold back half of the sleeve seal and slip it onto the sleeve.
2. Slide the sleeve (with the sleeve seal partially installed) onto the line.
3. Position the split sleeves over the line beads.
4. Slide the sleeve over the split sleeves and fold over the sleeve seal so that it covers the entire sleeve.
5. Install the coupling over the sleeve seal and torque to correct value.

NOTE: Torque values for the various sizes and types of couplings may be found by referring to the applicable Maintenance Instructions Manual. Some couplings will have the correct torque value marked on the outside of the band.

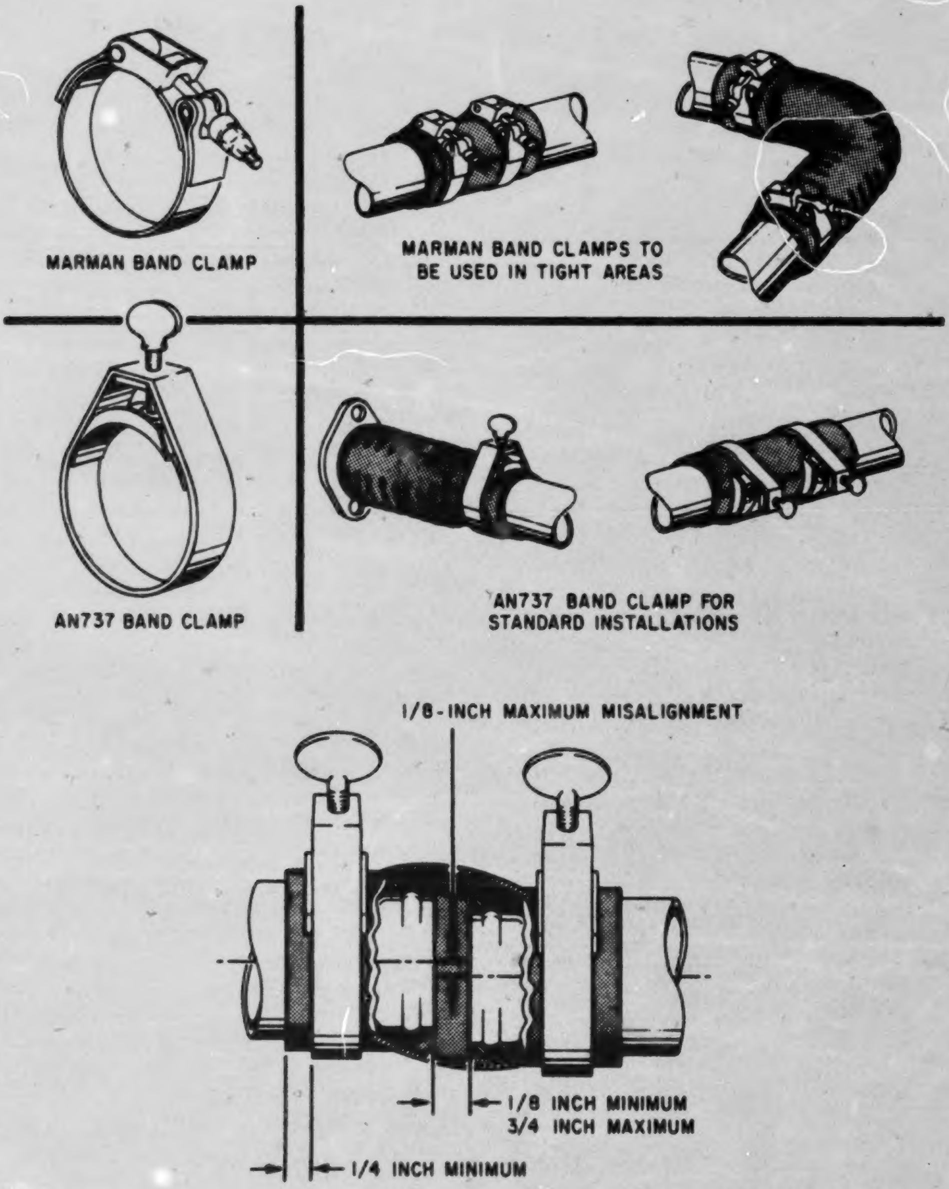
INSTALLING RIGID COUPLINGS.—To ease installation in restricted areas, some of the stiffness of the rigid coupling can be overcome by tightening the coupling over a spare set of flanges and gasket to the recommended torque value of the joint. Tap the coupling a few times with a plastic mallet before removing it.

When installing rigid couplings, follow the steps listed below and illustrated in figure 5-15:

1. Slip the V-band coupling over the flanged tube.
2. Place a gasket into one flange. One quick rotary motion assures positive seating of the gasket.
3. Hold the gasket in place with one hand while the mating flanged tube is assembled into the gasket with a series of vertical and horizontal motions to assure the seating of the mating flange to the gasket.

NOTE: View B of figure 5-15 illustrates the proper fitting and connecting of a rigid coupling, utilizing a metal gasket between the ducting flanges.

4. While holding the joint firmly with one hand, install the V-band coupling over the two flanges.
5. Press the coupling tightly around the flanges with one hand while engaging the latch.
6. Tighten the coupling firmly with a ratchet wrench. Tap the outer periphery of the coupling with a plastic mallet to assure proper alignment of the flanges in the coupling. This will seat the sealing edges of the flanges in the gasket. Tighten again, making sure the recommended torque is not exceeded.
7. Check the torque of the coupling with a torque wrench and tighten until the specified torque is obtained.
8. Safety wire the V-band as illustrated in figure 5-16 as an extra measure of security in the event of T-bolt failure. If the nut on the T-bolt is drilled for saftying, extend the safety wire to the nut so that it will pull on the nut in a clockwise (tightening) direction. Most V-band connectors will utilize a T-bolt with some type of self-locking nut.


MARMAN BAND CLAMP
MARMAN BAND CLAMPS TO BE USED IN TIGHT AREAS
AN737 BAND CLAMP
AN737 BAND CLAMP FOR STANDARD INSTALLATIONS
1/8-INCH MAXIMUM MISALIGNMENT
1/8 INCH MINIMUM
3/4 INCH MAXIMUM
1/4 INCH MINIMUM

AM. 1135

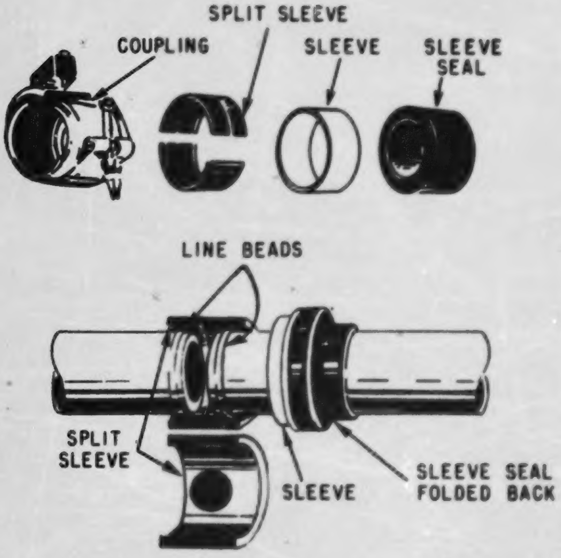
Figure 5-13.—Flexible line connectors.

eals

Joints around doors, canopies, windows, and ll other openings are made airtight by the use of rubber seals. A leaking seal will prevent pressurization of the cockpit or cabin or give marginal pressurization, depending on its size. All seals must therefore be inspected regularly for cuts, tears, cracks, and deterioration. Damaged seals must be patched or replaced as necessary.

Electrical Failures

Since all pressurization and air-conditioning systems have electrically controlled components, maintenance of these systems must include the related electrical circuits in many instances. Although an AE is generally called upon to locate and correct electrical troubles, the AME should be able to check circuits for loose connections, and even perform continuity checks when necessary. A knowledge of electrical symbols and the ability to read circuit diagrams is therefore necessary. Figure 5-17 illustrates the electrical symbols commonly found in schematic diagrams.



AM.91

Figure 5-14.—Installation of flexible line couplings.

Loose connections are located by checking all connectors in the circuit. A connector that can be turned by hand is loose and should be tightened handtight.

A continuity check is simply a matter of determining whether or not the circuit to the valve, or other electrically controlled unit, is complete. The check for continuity may be made with a test lamp which can be drawn from supply.

To perform a continuity check, the connector at the electrically controlled unit is first disconnected. Then, with all necessary switches and circuit breakers closed, the test lamp is connected into the circuit at the electrical connector. The lamp thus indicates whether or not the circuit is complete.

Continuity checks may also be made with the use of a multimeter. A multimeter is an instrument used for measuring resistance, voltage, or amperage. Using this instrument is primarily the responsibility of the AE; however, the AME may learn to use it by referring to Basic Electricity, NavPers 10086-B, Chapter 15. Remember, certain portions of this training manual are recommended supplemental reading for all AME personnel.

TROUBLESHOOTING

Troubleshooting is the process of locating a malfunctioning component or other unit in a system or mechanism. For the AME, troubleshooting is an important responsibility.

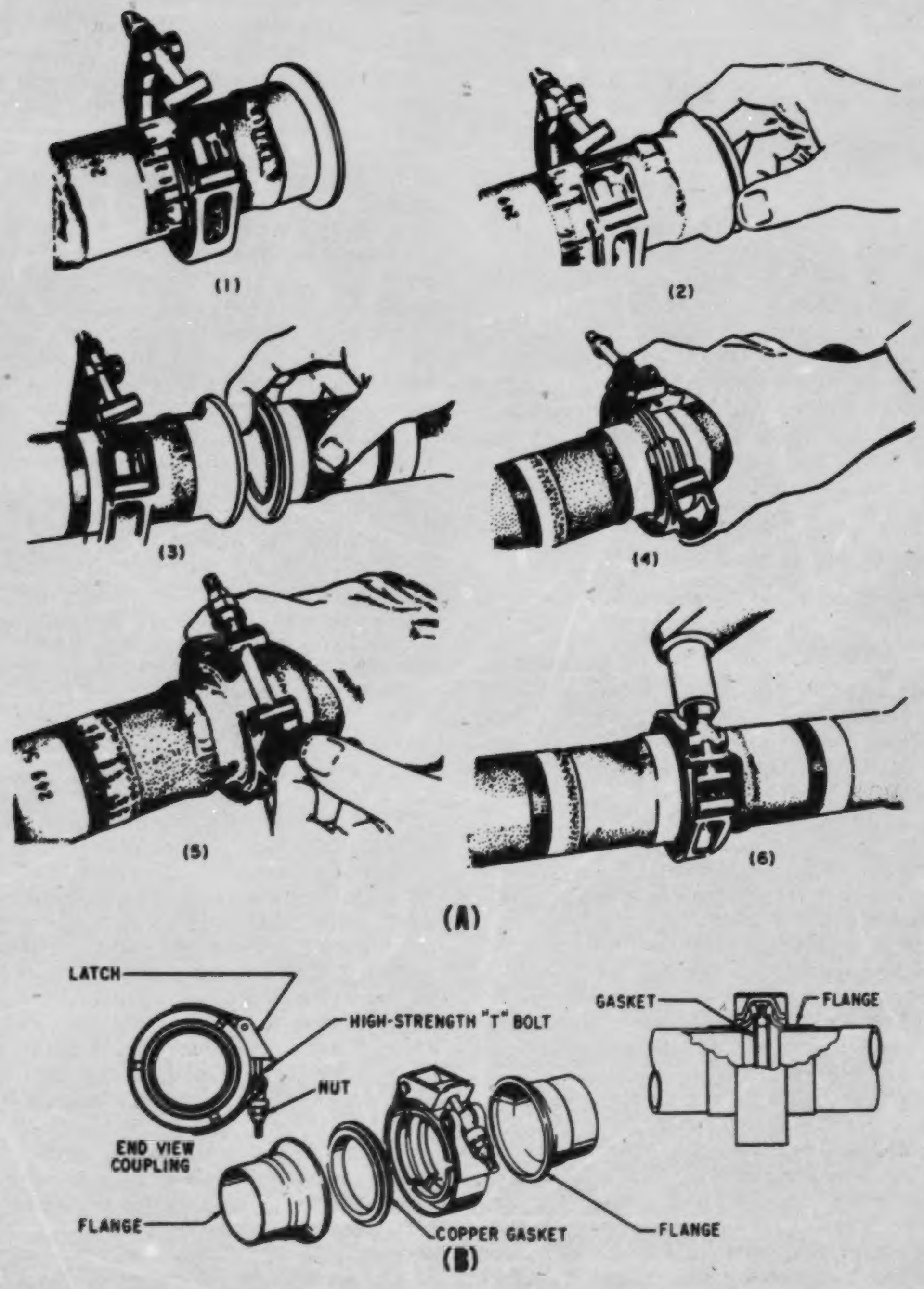
When a malfunction is reported concerning any of the components or systems that are maintained by the AME, he must be able to locate the trouble and correct the difficulty.

In order to troubleshoot intelligently, the AME must be familiar with the system at hand. He must know the function of each component in the system and have a mental picture of the location of each component in the system in relation to other components as well as the location of the component in the aircraft. This can be best achieved by studying the installation and schematic diagrams of the systems found in the applicable Maintenance Instructions Manual.

Use of Diagrams

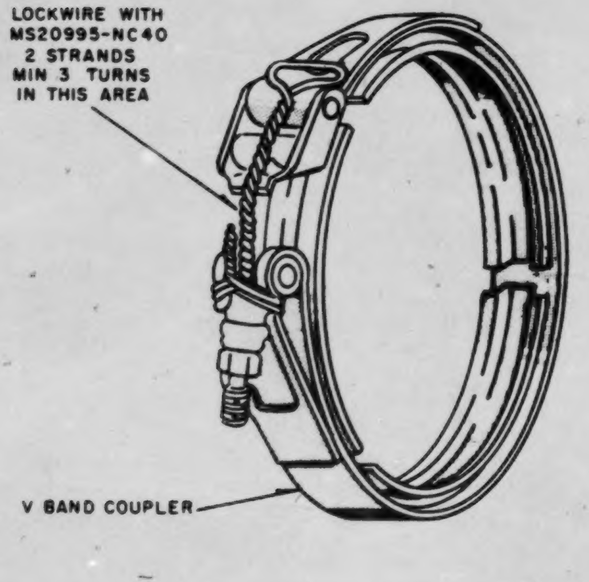
Each aircraft manufacturer is required to furnish diagrams of the various systems found in the aircraft as well as cross-sectional views of components that will aid in understanding their operation.

A diagram, whether it is an installation or schematic diagram, may be defined as a graphic representation of an assembly or system indicating the various parts and expressing the methods or principles of operation.


(1)
(2)
(3)
(4)
(5)
(6)
(A)
LATCH
HIGH-STRENGTH "T" BOLT
NUT
END VIEW COUPLING
GASKET
FLANGE
FLANGE
COPPER GASKET
FLANGE
(B)

AM.1136

Figure 5-15.—Installation of rigid line couplings.



AM.1137

Figure 5-16.—Safetying a V-band coupling.

INSTALLATION DIAGRAMS.—The top half of figure 5-3 is an example of an installation diagram. This is a diagram of the equipment pressurization system. It identifies each of the components in the system and shows their location within the aircraft on this principal view. If further detail was required, letters on the principal view (A, B, etc.) would refer to a detailed view located elsewhere on the diagram. Each detailed view is an enlarged drawing of a portion of the system or a portion of a component as applicable.

Diagrams of this type are used extensively throughout all aircraft Maintenance Instructions Manuals and are invaluable to maintenance personnel in identifying and locating components in the aircraft and understanding the operating principle of the various systems.

SCHEMATIC DIAGRAMS.—Figure 5-1 is an example of a schematic diagram of a typical air-conditioning and pressurization system. Diagrams of this type do not indicate the location of the individual components in the aircraft, but do locate the components with respect to each other within the system. For example, the cabin bleed-air shutoff valve is not located next to the dual temperature control valve in the aircraft. The diagram does indicate, however, that hot engine bleed air flows from the cabin bleed-air shutoff valve to the hot side of the dual temperature control valve.

Schematic diagrams of this type are used primarily in troubleshooting. Note that by referring to the legend in the diagram, the flow of bleed air can be traced throughout the system and the AME is able to differentiate between plumbing sections that duct hot bleed air, cooled bleed air, conditioned air, etc. Each component is identified by a name, and its location within the system can be ascertained by noting which lines lead into and out of each valve or unit.

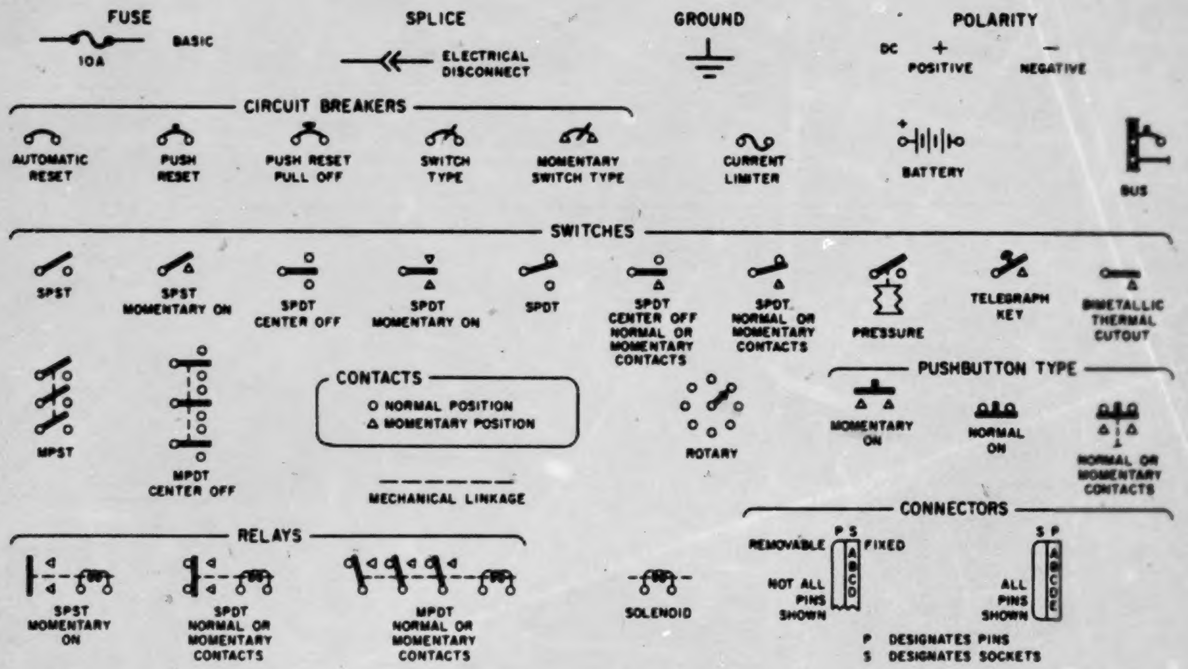
In tracing the flow of bleed air from the engine, it can be seen that the first unit in the line is a one-way check valve. The arrow on the check valve indicates the direction of flow through the valve. It is fairly obvious that the check valve is installed at this point to prevent bleed air from one engine entering the opposite engine in the event one engine is shut down.

Tracing the flow from the check valves the AME can see that bleed air branches and goes to the cabin bleed-air shutoff valve, to the ventilation suit subsystem, to the defogging subsystem, and to the air cycle refrigeration unit. It can be further seen that cooled bleed air leaving the turbine goes to the equipment cooling subsystem as well as to the cabin for cooling. Some of the cooled air goes through the water separator and some bypasses the water separator. By tracing airflow throughout the system and each component, the AME can gain a better understanding of how the system is designed to operate and will develop the ability to identify proper or faulty operation of each component when performing operational checks.

Schematic diagrams, like installation diagrams, are used extensively throughout all Maintenance Instructions Manuals. By studying each schematic diagram thoroughly, the AME is able to get a better understanding of the operation of the system and its components and can therefore troubleshoot more effectively.

Troubleshooting Procedures

Troubleshooting procedures are similar in practically all applications. The procedures covered in this section are certainly adaptable to almost all aircraft systems. Auto mechanics use these steps to find and repair automobile malfunctions. The AME can use these procedures to find and repair malfunctions within all the aircraft system for which he is responsible.


FUSE
10A
BASIC
SPLICE
ELECTRICAL DISCONNECT
GROUND
POLARITY
DC
+
POSITIVE
−
NEGATIVE
CIRCUIT BREAKERS
AUTOMATIC RESET
PUSH RESET
PUSH RESET PULL OFF
SWITCH TYPE
MOMENTARY SWITCH TYPE
CURRENT LIMITER
BATTERY
BUS
SWITCHES
SPST
SPST MOMENTARY ON
SPDT CENTER OFF
SPDT MOMENTARY ON
SPDT
SPDT CENTER OFF NORMAL OR MOMENTARY CONTACTS
SPDT NORMAL OR MOMENTARY CONTACTS
PRESSURE
TELEGRAPH KEY
BIMETALLIC THERMAL CUTOUT
MPST
MPDT CENTER OFF
CONTACTS
O NORMAL POSITION
Δ MOMENTARY POSITION
MECHANICAL LINKAGE
ROTARY
PUSHBUTTON TYPE
MOMENTARY ON
NORMAL ON
NORMAL OR MOMENTARY CONTACTS
CONNECTORS
P S
REMOVABLE
FIXED
NOT ALL PINS SHOWN
A B C D
S P
ALL PINS SHOWN
A B C D E
P DESIGNATES PINS
S DESIGNATES SOCKETS
RELAYS
SPST MOMENTARY ON
SPDT NORMAL OR MOMENTARY CONTACTS
MPDT NORMAL OR MOMENTARY CONTACTS
SOLENOID

AM.901

Figure 5-17.—Electrical symbols.

Basically, there are seven distinct steps to follow during troubleshooting. These steps are as follows:

1. Conduct a visual inspection. This inspection should be thorough and searching—checking all lines, linkages, and components for obvious damage; evidence of leakage, looseness, security, material condition, and proper installation; and servicing when applicable.

2. Conduct an operational check. The malfunctioning system or subsystem is checked for proper operation. This may be accomplished by utilizing special support equipment such as the environmental control test set covered later in this section or by utilizing aircraft power and equipment with the engines running. Each aircraft Maintenance Instructions Manual provides the steps to be taken in performing the operational checkouts of all the aircraft's systems. The operational checks and troubleshooting charts for each system are numbered so that when a malfunction occurs during a step in the operational checkout, the malfunction can be located under the same step number in the troubleshooting chart. The troubleshooting chart will provide a list of the most probable causes of the malfunction in the order of probability, along with a recommended remedy. In any case the AME must check the system out thoroughly, observing proper operation, sequence of events, etc. (Table 5-1 provides an example of a page from the troubleshooting chart for the components of the pressurization system illustrated in figure 5-1.)

3. Classify the trouble. Malfunctions usually fall into the basic categories—electrical, mechanical, and/or improper installation. Using the information acquired in steps 1 and 2, the AME determines under which classification the malfunction occurs. Proper use of the test set or a multimeter will additionally verify that the trouble is electrical or mechanical. Use of the Maintenance Instructions Manual when performing all maintenance tasks should prevent

Table 5-1.—Troubleshooting cabin pressurization.

Probable cause	Isolation procedure	Remedy
STEP 25 TROUBLE: CABIN PRESSURE IS LESS THAN 5.4 PSI		
Inadequate air supply.	Check external air supply.	Adjust external air supply.
Cabin safety valve.	Replace cabin safety valve with one known to operate properly. (Refer to paragraph 3-108.)	If normal operation results after replacement, use new valve.
Cabin dump valve.	Replace cabin dump valve with one known to operate properly. (Refer to paragraph 3-111.)	If normal operation results after replacement, use new valve.
Canopy seal.	Refer to Escape and Survival Systems, NavAir 01-85ADA-2-2.3.	
STEP 25 TROUBLE: CABIN PRESSURE IS GREATER THAN 5.6 PSI		
Cabin safety valve.	Replace cabin safety valve with one known to operate properly. (Refer to paragraph 3-108.)	If normal operation results after replacement, use new valve.
STEP 25 TROUBLE: CABIN PRESSURE FLUCTUATES		
Cabin safety valve.	Replace cabin safety valve with one known to operate properly. (Refer to paragraph 3-108.)	If normal operation results after replacement, use new valve.
STEP 26 TROUBLE: FLOW RATE EXCEEDS 3.5 POUNDS PER MINUTE		
Cabin safety valve.	Replace cabin safety valve with one known to operate properly. (Refer to paragraph 3-108.)	If normal operation results after replacement, use new valve.
Canopy seal.	Refer to Escape and Survival Systems, NavAir 01-85ADA-2-2.3.	
Defective structural sealing.	Check for leaks where wire bundles, ducts, and tubing enter cockpits.	Reseal where necessary and repeat step 23, paragraph 3-102.
STEP 31: TROUBLE: CABIN PRESSURE INCREASES TO MORE THAN 0.5 PSI		
Cabin safety valve.	Replace cabin safety valve with one known to operate properly. (Refer to paragraph 3-108.)	If normal operation results after replacement, use new valve.
Cabin dump valve.	Replace cabin dump valve with one known to operate properly. (Refer to paragraph 3-111.)	If normal operation results after replacement, use new valve.

Table 5-1.—Troubleshooting cabin pressure—Continued

Probable cause	Isolation procedure	Remedy
STEP 48 TROUBLE: CABIN PRESSURE INCREASES TO MORE THAN 0.5 PSI		
	Troubleshooting procedure is the same as that listed under STEP 28 TROUBLE: CABIN PRESSURE INCREASED TO MORE THAN 0.5 PSI.	
STEP 49 TROUBLE: PRESSURE GAGE READS LESS THAN 2.0 INCHES OF WATER		
Leakage at the ducts, couplings, plenum-pallet gasket connections, rubber grommets, or plenum relief valve.	Check system for leakage.	Disconnect air supply and stop leakage by realigning or resealing, and repeat step 46, paragraph 3-102.

improper installation. Something affecting the flow of gas or liquid (as could be the case in the vapor cycle air-conditioning system, covered later in this chapter) could be classified as a combination electrical/mechanical failure. Most mechanical failures should be found on the visual inspection; however, drive shaft failure on some of the air-conditioning valves is not readily apparent until the valve is operated. In some cases it may even be necessary to disconnect the valve from ducting so that the butterfly valve can be observed through the end opening. The position indicator on some valves can indicate that the valve is changing positions, which would be a false indication if the shaft was broken after the indicating mechanism, or if the butterfly valve was damaged in such a manner that the shaft would rotate without actually repositioning the valve.

4. Isolate the trouble. This step calls for sound reasoning, and a full and complete knowledge of how each component and the system should operate. During this step, the AME can make full use of his knowledge as well as full utilization of the system schematics to trace system operation and systematically eliminate components, until he arrives at a reasonable conclusion concerning the cause of the malfunction based on facts and deductive reasoning. Usually the trouble can be pinned down to one or two areas. By checking these individual areas or components the trouble can be isolated.

5. Locate the trouble. This step is used to eliminate unnecessary parts removal, thus saving time, money, and manhours. Once the AME has isolated the trouble to a certain area or component, a closer observation of the valve or component in operation should provide some obvious indication that it is not operating as specified in the MIM. If all evidence seems to indicate that the problem is electrical, the assistance of an AE should be requested.

6. Correct the trouble. This step is accomplished only after the trouble has been definitely pinpointed and there is no doubt that the AME's diagnosis is correct. Removal, replacement, or repair of the unit or system is accomplished utilizing the instructions provided in the applicable aircraft Maintenance Instructions Manual.

NOTE: While performing maintenance on any system, insure that the step-by-step procedures outlined in the MIM including CAUTIONS, WARNINGS, and SAFETY notes concerning the specific procedures are strictly complied with.

7. Conduct a final operational check. The affected component or system must be given an operational check following installation or after repair to verify proper system or component operation. The Maintenance Instructions Manual will provide the procedures for conducting the operational check. It will usually require operation of the system in various modes (manual and automatic for air-conditioning and pressurization systems) or through several cycles as applicable. Specified steps throughout the

repair procedure and the performing of the operational check must be observed and certified by a quality assurance representative or a collateral duty quality assurance representative from the work center performing the work. These steps are usually identified in the MIM by being underlined, or appearing in italics, or some other obvious method.

Operational Checks

An operational check of both the air-conditioning and pressurization system is required periodically and after maintenance on the system to verify proper operation. The air-conditioning system can generally be checked by turning up the aircraft and operating the system in both automatic and manual modes. On some aircraft, the air-conditioning system is operationally checked utilizing a test set. The pressurization system is checked utilizing an outside source of air.

NOTE: Only maintenance personnel who have been qualified for "turnup" of a specific aircraft may do so. These personnel receive turnup indoctrination and training by quality assurance personnel and must have their turnup authorization card in their possession during the turnup. Turnup by unauthorized personnel is specifically prohibited and could result in serious damage to the engines or the aircraft as well as personnel injuries.

CHECKING THE AIR CONDITIONING.—Ground checking of an air-conditioning system utilizing an Environmental Control System Test Set such as the AN/ASM-171 (XN-2) is the responsibility of personnel within the AE rating. The test set is simple to operate and provides a quick and easy method to differentiate between electrical and mechanical malfunctions. The test set is capable of checking almost all electrical components of the air-conditioning system by systematically checking each component in a specific order until the cause of malfunction is pinpointed. The AME should work with the AE while performing the operational check. By observing the position indicators of the various system valves, the AME can verify proper opening, closing, and modulating of the valve as the test is being conducted. The test set will inform the AE if the electrical portion of the valve is operating correctly but may fail to indicate a broken valve drive shaft, binding gear train, stuck valve, etc.

Ground checking of the air-conditioning system during an aircraft turnup is a relatively simple procedure and is performed in practically the same manner on all aircraft. If the electrical components were checked using the test set and all malfunctions corrected, it is not necessary to recheck each component for proper operation. If the test set was not used, the AE will have to remove the cannon plugs on the individual components as the air-conditioning control switches are placed in their various positions and take voltage readings as specified in the MIM.

During the operational test, the engines should be running at a constant output at high thrust and the canopy should be closed.

The procedures and the desired results expected in each mode of operation are specified in the applicable MIM, and they should be performed in the correct sequence. If any trouble becomes apparent during a procedure, it must be corrected before proceeding to the next step. Troubleshooting tables in the MIM's list the more common troubles that could occur in the system. Under each trouble is listed the probable cause or causes, isolation procedures, and remedy. The troubles in the tables are arranged to correspond with the step of the operational check where the trouble occurred.

Basically, the operational test (manual mode) consists of placing the MAN/RAM AIR switch in the hot and cold positions and checking for proper change in the temperature of air entering the cockpit. Next, the MAN/RAM AIR switch is placed in the automatic mode position. Move the automatic temperature control knob to different settings and observe the temperature changes expected. There should be no uncomfortable pressure fluctuations throughout these tests, and the temperature change should occur shortly after a change is initiated.

CHECKING COCKPIT PRESSURIZATION.—After any repair work on the pressurized surfaces of the cockpit, and prior to the initial pressurized flight, the cockpit must be checked for pressure tightness. Ground pressurization is accomplished by the introduction of air pressure from an external source into the cockpit through a connector fitting usually located in the cockpit pressure bulkhead.

The exact procedure for making leakage tests varies somewhat with different models of aircraft and should be done under the direct supervision of a senior AME. No personnel should be allowed in the cockpit during the pressure check. Detailed instructions are outlined in each aircraft Maintenance Instructions Manual and should be strictly complied with in all pressure checks. Usually included in these instructions are a list of equipment needed for making the test, the amount of pressure to be used, and the allowable pressure drop per minute.

Basically, the ground check of an aircraft's pressurization system consists of the following steps:

1. Place the cabin pressure regulator ground test handle to the TEST ONLY ALL OFF position.
2. Remove the cabin pressure-altitude indicator.
3. Connect pressure gage to the cabin pressure gage test connection fitting in nosewheel well.
4. Connect an external air supply to the canopy seal ground test fitting and inflate the seal (canopy closed), using the pressure specified in the applicable MIM.
5. Connect the cabin pressure tester air supply to the cabin pressure ground test fitting.

NOTE: On most aircraft this fitting is located in the nosewheel well.

6. Apply recommended pressure utilizing the tester and observe the opening of the cabin safety valve.

CAUTION: Do not allow the cabin pressure to exceed the recommended limits. This could happen if the cabin safety valve is defective. Do not allow any personnel inside the aircraft when performing pressure checks. Insure that main doors, escape hatches, etc., are properly secured before applying pressure and that they remain closed until pressure is reduced to 0 psi.

7. Reduce pressure to 0 psi.
8. Position the cabin pressure regulator ground test handle to the TEST ONLY DIFF ON position.
9. Reapply pressure as specified in the MIM and observe proper operation of the cabin pressure regulator.
10. Remove pressure, gages, air supply, and any adapters utilized to apply pressure. Reinstall the cabin pressure-altitude indicator. Cap all test connections. Return the cabin pressure regulator ground test handle to the flight position and safety wire.

NOTE: Some aircraft MIM's call for checking the cabin dump valve immediately following the check of the cabin safety valve. If required, this is accomplished with conditions the same as they were for step 6 except the cabin dump valve should be in the DUMP position. There should be no pressure buildup as pressure is applied with the tester because pressure is relieved through the cabin safety valve.

TESTING FOR CARBON MONOXIDE CONTAMINATION.—Although testing for carbon monoxide contamination applies mainly to aircraft having reciprocating engines, performing this test is closely related to cockpit leakage testing and is therefore discussed here. Performance of the carbon monoxide contamination test is a requirement for advancement to AME2.

The most common sources of carbon monoxide are exhaust fumes from reciprocating engines and the gases liberated when guns are fired. Another common source not usually considered is tobacco smoke. Heavy smokers may have 7 percent of the hemoglobin in their red blood cells immobilized in this manner. This may lower the ceiling for these pilots as much as 5,000 feet because the available oxygen carrying capacity of the blood is correspondingly lowered.

Carbon monoxide is an odorless, tasteless, colorless, and deadly poisonous gas. Its effect is dangerous due to the high rate of absorption in the bloodstream when inhaled even in minute concentrations.

The first recognizable physiological symptom accompanying carbon monoxide poisoning is the sensation of tightness across the forehead, together with possible slight headache and dilation of the blood vessels.

To guard against the entrance of carbon monoxide into occupied compartments, the chief concern should be aimed at testing the efficiency of vapor sealing. As stated in NavAir Instruction 3750.1, all maintenance personnel should observe a program of strict preventive maintenance regarding proper sealing of all openings adjacent to occupied compartments.

All seals should be inspected for physical condition and integrity at each periodic inspection interval. Carbon monoxide tests should be conducted in accordance with MIL-STD-800 to ascertain that allowable limits of contamination are not being exceeded.

All seals, boots, access plates, firewall areas, ventilating ducts, windshield canopy seals, cockpit bulkheads and decks, and other compartments that form a barrier between the cockpit areas and potential sources of carbon monoxide must be inspected. After repair or modification work, all compartment openings must be effectively resealed.

Carbon monoxide tests are specified in NavAir Instruction 3750.1 and are performed with a bulb type colorimetric carbon monoxide indicator. This instrument consists of a sampling bulb, indicator tube, calibration chart, and a carrying case.

The sampling bulb is a rubber bulb (similar to an ear syringe) which is used to draw air samples through the indicator tube. The indicator tube is a small glass tube filled with a treated substance (material whose color reacts to carbon monoxide). The tubes are sealed at the time of manufacture by drawing the ends to a point. The sealed ends are broken off immediately prior to use. NOTE: The indicator tubes are used for one test only.

Testing is performed by inserting the indicator tube (with ends broken off) in the sampling bulb and drawing a sample of the air from the cockpit through the tube. NOTE: These samples should be drawn in accordance with the instructions included with the instrument. The presence of carbon monoxide is indicated by a change in the color of the chemically treated material in the tube.

The color of the contents of the exposed indicator tube is checked against colors on the calibration chart to determine the percentage of carbon monoxide content in the air. NOTE: Comparison of the exposed indicator tubes with the chart should be made as soon as possible and not later than 5 minutes after the test.

In determining the condition and integrity of seals, tests for carbon monoxide with the colorimetric indicator should be supplemented with tests for leakage such as the following:

1. The light beam method. When using this method, sunlight or a bright light (at night) is used to visually find cracks between the canopy and the aircraft or other openings.

2. The smoke trail method. The smoke trail method is used to find openings which are not visible with a light. When using this method, the canopy and other openings are closed and smoke is forced into the cockpit. Leaks are located by the leaking smoke. An acceptable device for smoke testing is the Highland Engineering Company smoke generator.

VAPOR CYCLE AIR-CONDITIONING SYSTEM

Vapor cycle systems make use of the scientific fact that a liquid can be vaporized at any temperature by changing the pressure above it. Water, at sea level barometric pressure of 14.7 psi, will boil if its temperature is raised to 212° F. The same water in a closed tank under a pressure of 90 psi will not boil at less than 320° F. If the pressure was reduced to 0.95 psi by a vacuum pump, the water would boil at 100° F. If the pressure was reduced further, the water would boil at a still lower temperature; for instance, at 0.12 psi, boiling of water would occur at 40° F. Water can be made to boil at any temperature if the pressure corresponding to the desired boiling temperature can be maintained.

Liquids that will boil at low temperatures are the most desirable for use as refrigerants. Comparatively large quantities of heat are absorbed when liquids are evaporated; that is, changed to a vapor. For this reason, liquid Freon 12 or 22 is used in most vapor cycle refrigeration units whether used in aircraft or in home air conditioners and refrigerators.

If liquid Freon 12 were poured into an open container surrounded by standard sea level pressure, it would immediately begin to boil at temperatures above -22° F. There would be a continuous flow of heat from the warm surrounding air through the walls of the container to the boiling Freon. Moisture from the air would condense and freeze on the exterior of the container.

The system would work satisfactorily insofar as cooling alone is concerned. A drum of Freon could be connected to a coil and the vaporized Freon piped outdoors. An installation such as this would provide satisfactory refrigeration, but the cost of replacing the refrigerant would be prohibitive. Because of the cost involved, it is desirable to use the refrigerant over and over. To accomplish this, additional equipment over and above that already mentioned is required.

VAPOR CYCLE THEORY

Refrigerant used in the vapor cycle refrigeration system occurs as both a liquid and as a vapor. Conversion from a liquid to a vapor will occur at temperatures above -21° F at sea level. If the refrigerant pressure is increased, conversion to a vapor will occur at higher temperatures. Maximum heat transfer efficiency occurs when the refrigerant is at the boiling point (that point where the liquid will vaporize).

The refrigerant must be delivered to the evaporator as a liquid if it is to absorb large quantities of heat. Since it leaves the evaporator in the form of a vapor, some way of condensing the vapor is necessary. To condense the refrigerant vapor, the heat surrendered by the vapor during condensation must be transferred to some other medium. For this purpose, water or air is ordinarily used. The water or air must be at a temperature lower than the condensing temperature of the refrigerant. At any given pressure the condensing and vaporizing temperature of a fluid are the same. If a refrigerant which vaporizes at 40° F is to be condensed at the same temperature, water or air at a lower temperature is needed. Obviously, if water or air at this lower temperature were available, mechanical refrigeration would not be required. As the temperature of available water or air is usually always higher than the temperature of the boiling refrigerant in the evaporator, the refrigerant must be condensed after it leaves the evaporator. In order to condense the vapor, its pressure must be increased to such a point that its condensing temperature will be above the temperature of the water or air available for condensing purposes. For this purpose a compressor is needed. After the pressure of the refrigerant vapor has been increased sufficiently, it may be liquefied in the condenser with comparatively warm water or air.

The only reason that the compressor and condenser are introduced into the system is to enable the same refrigerant to be used over and over again. The cost of compressing and condensing the vaporized refrigerant is far less than the cost of continuously purchasing refrigerant to replace that which would be lost due to evaporation.

In a practical refrigeration circuit, liquid flows from the receiver to the expansion valve which is essentially nothing more than a needle valve. The compressor maintains a difference in pressure between the evaporator and the condenser. Without the expansion valve, this difference in pressure could not be maintained. The expansion valve separates the high-pressure part of the system from the low-pressure part. It acts as a pressure reducing valve because the pressure of the liquid flowing through it is lowered. Only a small trickle of refrigerant fluid flows through the valve into the evaporator. The valve is always so adjusted that only just as much liquid can pass through it as can be vaporized in the evaporator.

The liquid that flows through the evaporator is entirely vaporized by the heat flowing through the walls of the evaporator. This heat has been removed from the air being cooled.

After leaving the evaporator, the vaporized refrigerant flows to the compressor where its pressure is raised to a point where it can be condensed by the condenser-air flow available. After being compressed, the vapor flows to the condenser. Here, the walls of the condenser are cooled by the water or air; and as a result, the vapor is liquefied. Heat is transferred from the condensing vapor to the water or air through the walls of the condenser. From the condenser the liquid refrigerant flows back to the receiver and the cycle is then repeated.

DESCRIPTION/OPERATION (TYPICAL SYSTEM)

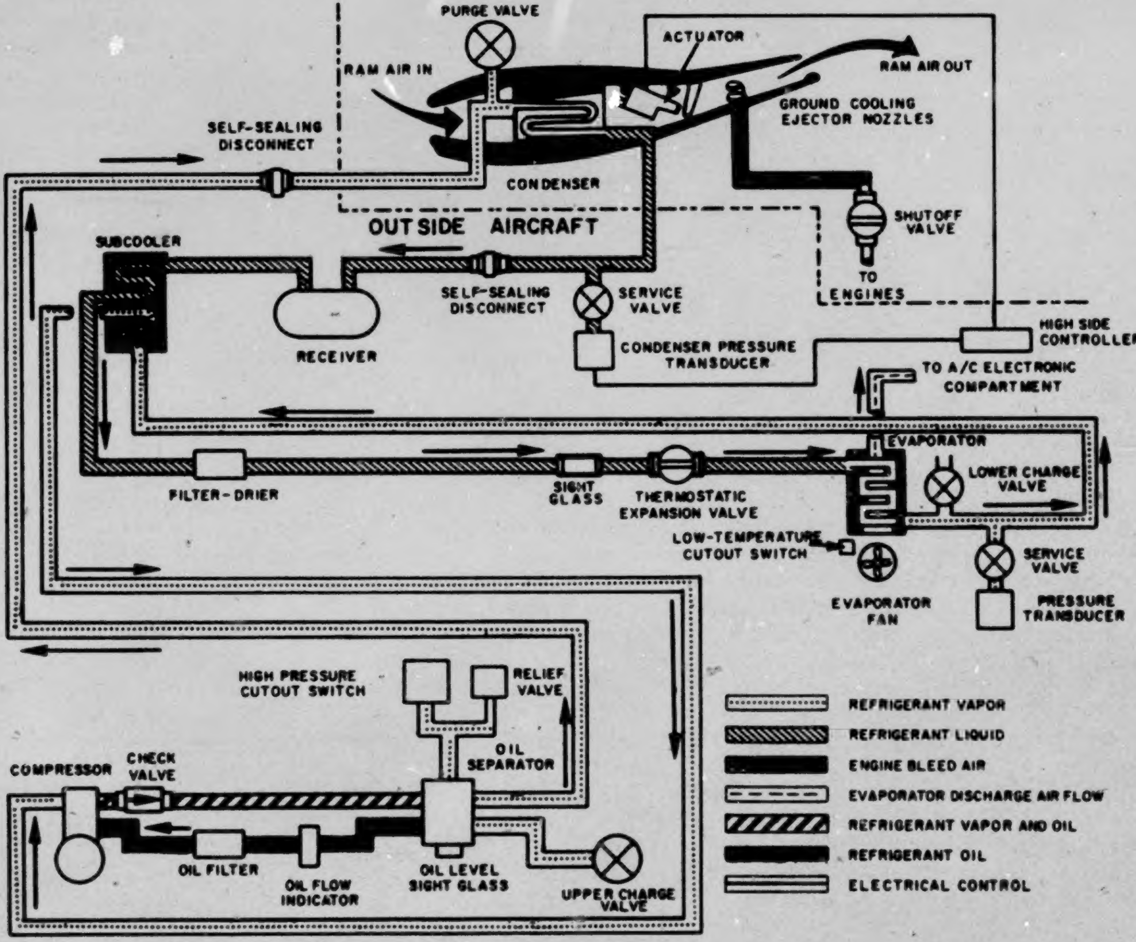
Various avionic packages aboard some modern Navy aircraft generate heat in quantities that would be detrimental to their operation if some type of cooling facilities were not provided. The Grumman Aircraft Engineering Corporation chose a Freon 12 vapor cycle refrigeration package to provide avionics equipment cooling in the E-2 "Hawkeye" aircraft. This model, the VEA6-1, is described in this section. The basic difference between the basic vapor cycle system and this model is the method of compensating for the variations in ram-air temperature, and the variation in the flow of ram air, which is dependent on aircraft speed.

Figure 5-18 is a schematic diagram of this system.

In the E-2 configuration, the vapor cycle system cools, filters, and distributes avionics compartment air at a temperature of 38° ± 5° F.

The system consists of a vapor cycle cooling scoop assembly, an evaporator group assembly, and an air distribution ducting interconnected by refrigerant lines and electrical wiring.

The evaporator assembly (fig. 5-19) is a compact, quick-change package that can be easily installed, removed, and serviced as a unit. Five quick-disconnect couplings, two shock mounts, and two plug type mounts are installed on the assembly's tubular frame. The main components of the evaporator assembly include electrical and temperature controls; a hydraulic-motor-driven, self-lubricated Freon compressor; a receiver; a subcooler; an expansion valve; an evaporator and hydraulic-motor-driven fan; and an oil separator.


PURGE VALVE
RAM AIR IN
ACTUATOR
RAM AIR OUT
GROUND COOLING EJECTOR NOZZLES
SELF-SEALING DISCONNECT
CONDENSER
OUTSIDE AIRCRAFT
SHUTOFF VALVE
TO ENGINES
SUBCOOLER
SELF-SEALING DISCONNECT
SERVICE VALVE
RECEIVER
CONDENSER PRESSURE TRANSDUCER
HIGH SIDE CONTROLLER
TO A/C ELECTRONIC COMPARTMENT
EVAPORATOR
LOWER CHARGE VALVE
FILTER-DRIER
SIGHT GLASS
THERMOSTATIC EXPANSION VALVE
LOW-TEMPERATURE CUTOUT SWITCH
SERVICE VALVE
EVAPORATOR FAN
PRESSURE TRANSDUCER
HIGH PRESSURE CUTOUT SWITCH
RELIEF VALVE
OIL SEPARATOR
COMPRESSOR
CHECK VALVE
OIL FILTER
OIL FLOW INDICATOR
OIL LEVEL SIGHT GLASS
UPPER CHARGE VALVE
REFRIGERANT VAPOR
REFRIGERANT LIQUID
ENGINE BLEED AIR
EVAPORATOR DISCHARGE AIR FLOW
REFRIGERANT VAPOR AND OIL
REFRIGERANT OIL
ELECTRICAL CONTROL

AM.1138

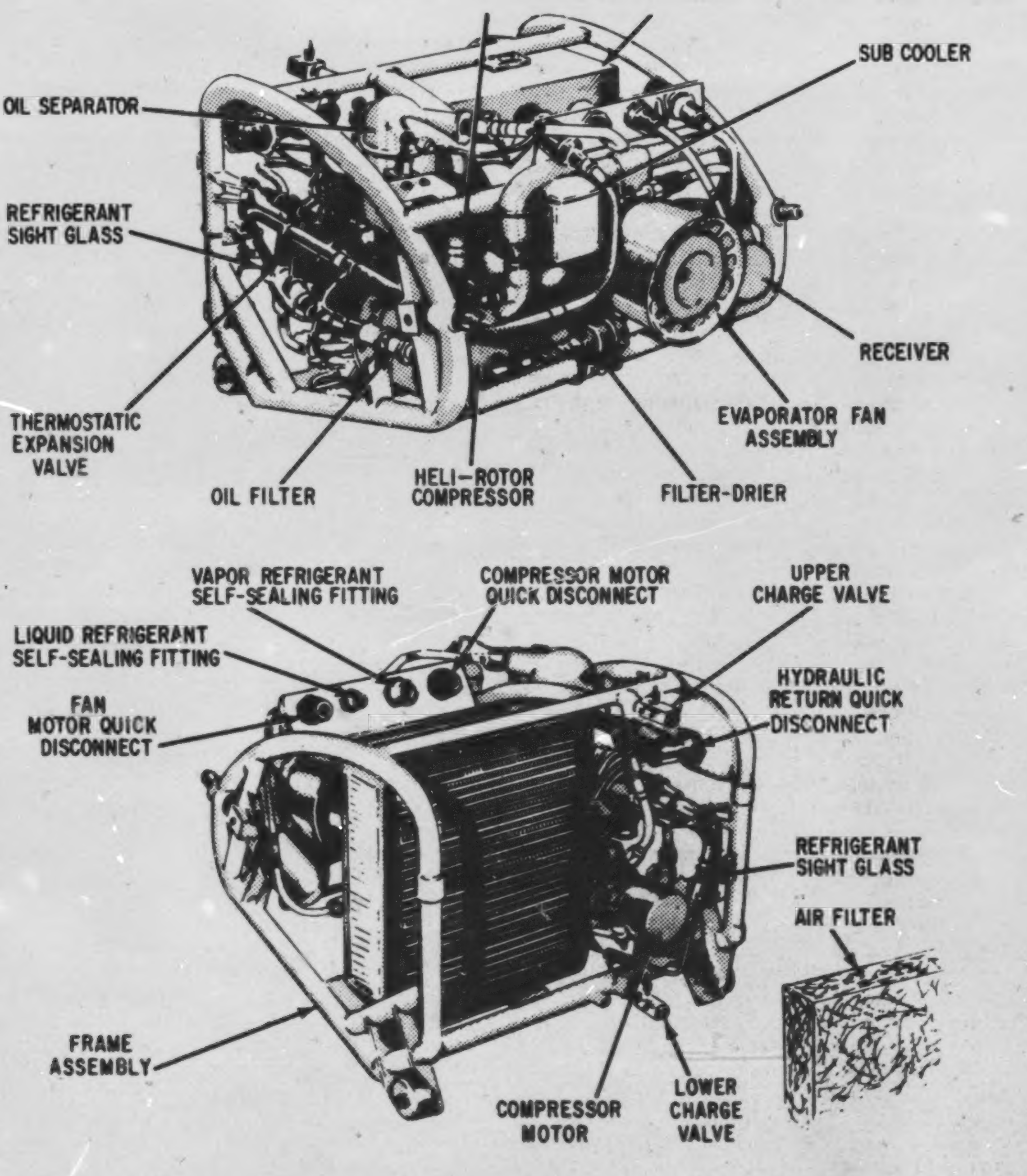
Figure 5-18.—Vapor cycle air-conditioning system.

The vapor cycle cooling scoop assembly is mounted on the top of the fuselage and consists of a condenser assembly, ejector nozzles, an actuator and flap, and a refrigerant pressure actuator control switch.

The Freon in the closed system is considered the primary coolant, and the forced air that is drawn through the evaporator in a continuous cycle is the secondary coolant.

The electronic equipment is cooled by the secondary coolant, which removes heat by direct contact with the equipment to be cooled and the transfer of this heat to the primary coolant through the evaporator assembly.

A header assembly attached to the discharge side of the evaporator assembly directs the secondary coolant air to distribution ducts throughout the electronic equipment compartment. A filter between the header assembly and the evaporator assembly removes dirt and dust particles and traps moisture from the air.


SUB COOLER
OIL SEPARATOR
REFRIGERANT SIGHT GLASS
RECEIVER
EVAPORATOR FAN ASSEMBLY
THERMOSTATIC EXPANSION VALVE
OIL FILTER
HELI-ROTOR COMPRESSOR
FILTER-DRIER
VAPOR REFRIGERANT SELF-SEALING FITTING
COMPRESSOR MOTOR QUICK DISCONNECT
UPPER CHARGE VALVE
LIQUID REFRIGERANT SELF-SEALING FITTING
HYDRAULIC RETURN QUICK DISCONNECT
FAN MOTOR QUICK DISCONNECT
REFRIGERANT SIGHT GLASS
AIR FILTER
FRAME ASSEMBLY
COMPRESSOR MOTOR
LOWER CHARGE VALVE

AM.94

Figure 5-19.—Evaporator assembly.

The primary coolant refrigerant (Freon 12) is in a closed system consisting of the evaporator group assembly and the condenser group assembly. The refrigerant circulates between the evaporator group assembly (where it absorbs heat) and the condenser group assembly where it discharges or dissipates the heat to the atmosphere through the vapor cycle scoop.

During flight, ram air flowing through the scoop cools the condenser group assembly. The airflow through the scoop is controlled by a condenser pressure control system. The actuator in the scoop modulates the airflow through the scoop to provide sufficient cooling for condensation of the refrigerant.

When the aircraft is on the ground with engines running and ram-air flow is insufficient for cooling, an ejector air shutoff valve opens to permit engine bleed air to discharge through the ejector assembly. The ejector consists of a set of tubes that permit bleed air to escape in the ram-air duct behind the condenser. The escaping bleed air creates a negative pressure (suction) area behind the condenser and causes ambient air to be drawn into the scoop and across the condenser.

If the heat load applied to the evaporator and the ram-air temperature and flow were constant, a simple orifice would be all that was required to control the boiling point of the refrigerant entering the evaporator. Since these three factors are not constant, they must be compensated for. In the model VEA6-1 system, if the heat load is changed, the flow of refrigerant is changed by utilizing a thermostatic expansion valve in place of a fixed orifice. The pressure of the refrigerant in the evaporator is maintained constant, regardless of the refrigerant flow, by varying the speed of the compressor.

When the EQUIPMENT COOLING switch is set to ON, solenoid-operated shutoff valves are energized and hydraulic pressure is directed to the evaporator fan motor and the compressor motor. The compressor motor will be automatically shut off when either aircraft engine is in autofeather and the landing gear is down. The evaporator fan motor will continue to operate.

With the evaporator fan and compressor motors operating, low-pressure, low-temperature refrigerant Freon 12 vapor enters the compressor assembly through the low-pressure line leading from the evaporator assembly outlet. The vapor entering the compressor inlet combines with lubricating oil that is fed to the compressor. The oil-refrigerant mixture is compressed to raise its condensing temperature. From the compressor, the high-temperature, high-pressure mixture flows to the oil separator where the oil is removed from the refrigerant vapor, filtered, and fed back to the compressor.

If the refrigerant vapor pressure exceeds 250 ± 5 psi in the line downstream from the oil separator, the high-pressure cutout switch will cause the cockpit EQUIP COOLING caution light to illuminate and the compressor motor solenoid valve to shut off hydraulic pressure to the compressor motor, thus shutting down the compressor. If the cutout switch failed to operate properly, the relief valve in the compressor discharge line would relieve the system of pressure in excess of 325 psi.

Refrigerant vapor from the oil separator next enters the condenser assembly where ram air lowers its temperature and changes the vapor to a liquid. Refrigerant pressure on the high side of the system is controlled by regulating the amount of cooling air flowing across the condenser. A pressure transducer in the high side refrigerant line provides a signal to a control amplifier which in turn causes the control actuator and flap to open and close as necessary to regulate pressure. The system is calibrated so that the condenser flap is fully closed when high side pressure is 107 ± 3 psi; fully opened at 151 ± 3 psi condensing pressure; and modulates the flap travel for intermediate pressures within that range.

If the cooling air is inadequate to maintain the pressure at 151 ± 3 psi with the flap fully open, the system pressure will exceed the control range. When the pressure reaches 250 ± 5 psi, the high-pressure cutout switch will shut down the vapor cycle system.

From the condenser assembly, liquid Freon flows to the receiver in the evaporator group assembly. The receiver stores surplus refrigerant and thereby prevents surges in the refrigerant flow rate. Liquid refrigerant flowing from the receiver passes through a subcooler and then through a filter drier, where foreign matter and water are removed. Before entering the thermostatic expansion valve, the liquid refrigerant passes through a sight glass which provides a visual indication of flow and proper refrigerant charge.

The refrigerant is metered by the thermostatic expansion valve and then enters the evaporator assembly. The hydraulic-motor-driven evaporator fan forces warm electronic equipment compartment air through the evaporator assembly where it is cooled by transfer of heat to the refrigerant. The refrigerant leaves the evaporator as a superheated vapor.

The temperature of evaporator discharge air to the equipment compartment is controlled by controlling the speed of the compressor motor. The evaporator pressure control system maintains the refrigerant pressure within a specified range so that the average temperature range of the refrigerant is between 29.8° and 32.9° ± 0.6° F. This temperature range consequently controls air temperature to approximately 38°. The difference between the air and refrigerant temperatures is due to the efficiency of the heat exchanger.

If the equipment compartment temperature increases, refrigerant pressure on the low side will also increase. The increase in pressure is sensed by a transducer located in the compressor inlet line and a signal is sent to the evaporator pressure control system amplifier. The amplifier in turn sends an appropriate signal to the servo portion of the compressor hydraulic motor calling for a speed increase to prevent pressure increase and thus maintain a constant refrigerant pressure. If the temperature increase calls for a compressor motor speed above a maximum of 12,000 rpm, the temperature rise cannot be compensated for and the refrigerant pressure will rise. At 250 ± 5 psi compressor discharge pressure, the high side cutout switch will shut the vapor cycle system down.

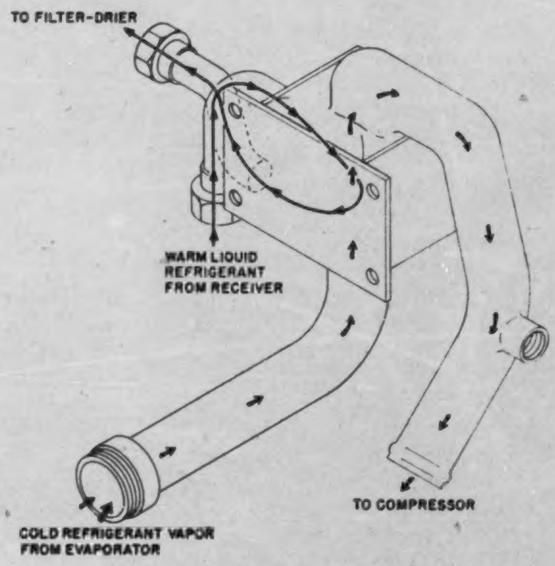
If the equipment compartment temperature drops, a reverse situation exists. Compressor motor speed will decrease to a minimum of 4,000 rpm. If the temperature (at the fan inlet continues to drop beyond the range which can be compensated (30° F), the low temperature cutoff switch deenergizes the compressor power relay and shuts down the compressor motor. The refrigerant stops flowing while the evaporator fan motor continues to circulate compartment air. When the fan inlet temperature rises to 40° ± 2° F, the compressor is cut in and refrigerant flows through the evaporator and the subcooler and returns to the compressor to repeat the cycle.

COMPONENTS

The purpose and the operation of each major component in the vapor cycle system are discussed in this section so that the AME will have a better understanding of proper system and component operation.

Subcooler

The subcooler (fig. 5-20) is a heat exchanger containing passages for liquid Freon from the receiver on its way to the evaporator and cold Freon gas leaving the evaporator on its way to the compressor.


TO FILTER-DRIER
WARM LIQUID REFRIGERANT FROM RECEIVER
TO COMPRESSOR
COLD REFRIGERANT VAPOR FROM EVAPORATOR

AM. 95

Figure 5-20.—Subcooler.

The purpose of the subcooler is to increase the efficiency of the system by cooling the refrigerant after it leaves the receiver, thereby preventing premature vaporization or flash off after passage through the expansion valve and before it reaches the evaporator. As stated previously, the refrigeration effect takes place when the Freon changes state from liquid to gas. Premature flash off would result in keeping additional refrigerant from evaporating and would have no useful effect on the primary cooling load required of the package.

The liquid on the way to the thermostatic expansion valve is relatively warm in comparison to the cold gas leaving the evaporator. Although the gas leaving the evaporator has absorbed heat from the air being circulated through the evaporator, its temperature is still in the vicinity of 40° F. This cool gas is fed through the subcooler where it picks up additional heat from the relatively warm liquid Freon 12 that is flowing from the receiver. This heat exchange causes the liquid to be subcooled to a level that insures little or no flash gas on its way to the evaporator.

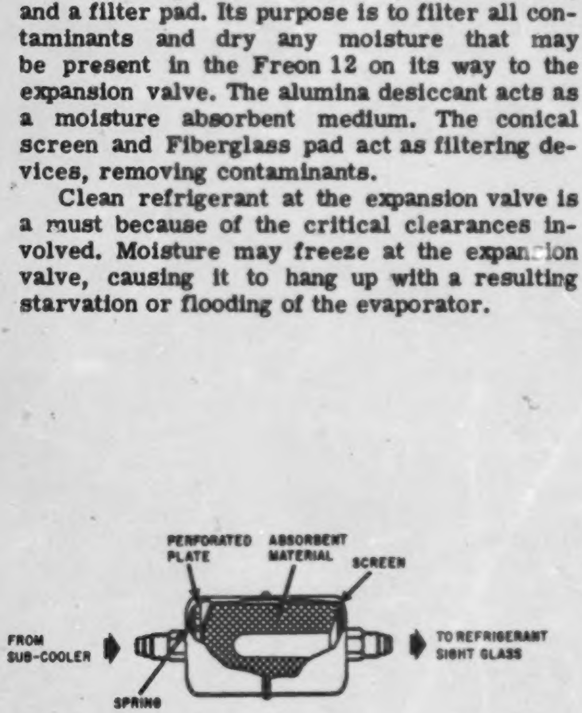
Receiver

The receiver acts as a reservoir for the liquid Freon 12 refrigerant. The fluid level in the receiver varies with system demands. During peak cooling periods, there will be less liquid than when the load is light. The prime function of the receiver is to insure that the thermostatic expansion valve is not starved for refrigerant under heavy cooling load conditions.

Filter Drier

A filter-drier (fig. 5-21) unit is installed in the plumbing between the subcooler and the sight glass. The unit is essentially a sheet-metal housing with inlet and outlet connections and containing alumina desiccant, a filter screen, and a filter pad. Its purpose is to filter all contaminants and dry any moisture that may be present in the Freon 12 on its way to the expansion valve. The alumina desiccant acts as a moisture absorbent medium. The conical screen and Fiberglass pad act as filtering devices, removing contaminants.

Clean refrigerant at the expansion valve is a must because of the critical clearances involved. Moisture may freeze at the expansion valve, causing it to hang up with a resulting starvation or flooding of the evaporator.



AM. 96

Figure 5-21.—Filter drier.

The filter-drier unit is a "throw away type" and is replaced whenever the charge is dumped from the unit after being in service for a reasonable period of time, or when filter-drier operation is doubtful.

Sight Gage

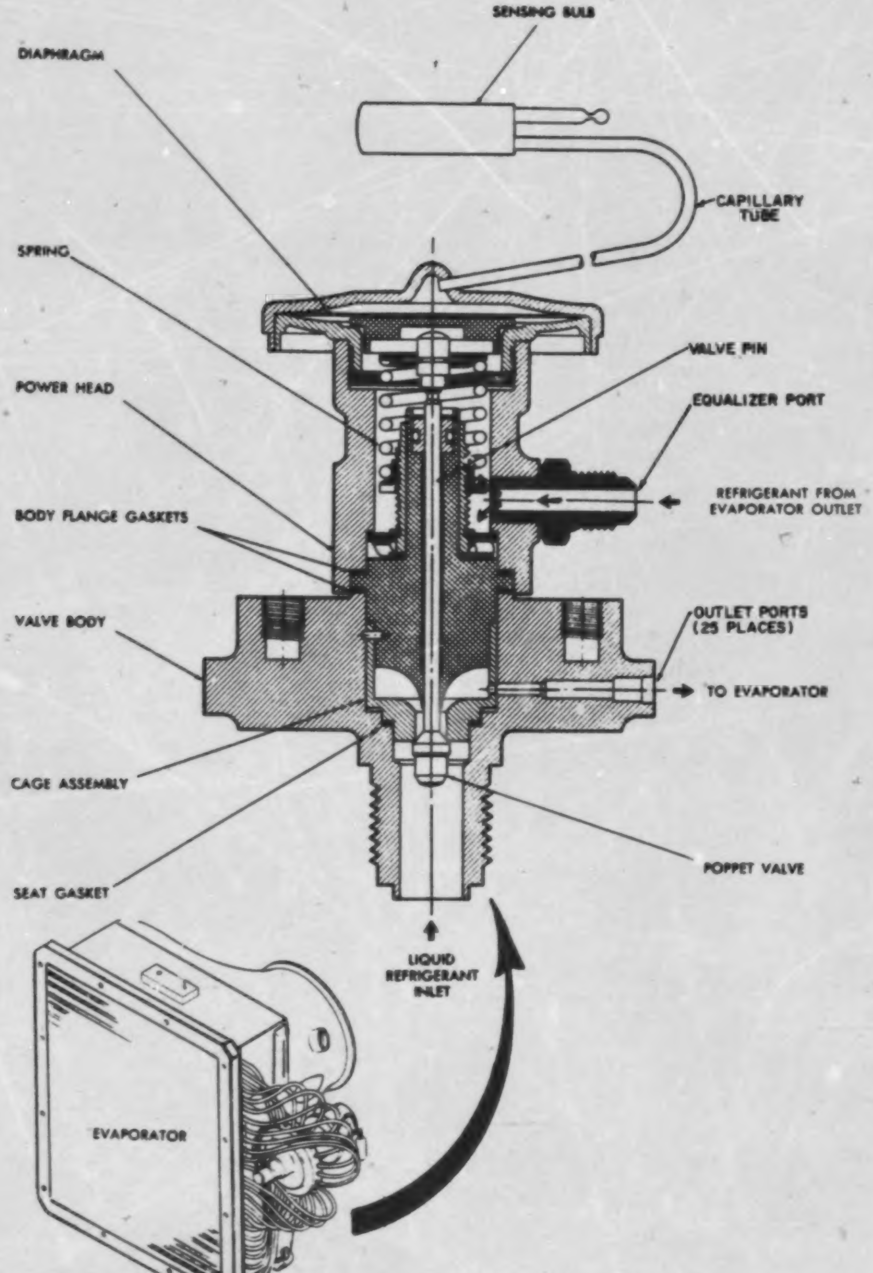
To aid in determining whether servicing of the refrigerating unit is required, a sight gage is installed in the line between the filter-drier and the thermostatic expansion valve. The gage assembly consists of a fitting having windows on both sides, permitting a view of fluid passage through the line.

During refrigeration unit operation, if a steady flow of Freon refrigerant is observed through the sight glass, this is an indication that sufficient charge is present. If the unit requires additional refrigerant, an indication will be given by the presence of bubbles in the sight glass. Since Freon is a colorless gas or liquid, a red colored dye may be added to the liquid to facilitate leak detection. This is usually accomplished upon initial charging of the system.

Thermostatic Expansion Valve

The thermostatic expansion valve (fig. 5-22) is mounted in close proximity to the evaporator and acts as a device to meter the flow of refrigerant into the evaporator, depending upon system demand. Efficient evaporator operation is dependent upon the precise metering of liquid refrigerant into the heat exchanger for evaporation. As was previously stated, if heat loads on the evaporator where constant, an orifice size could be calculated and used to regulate the refrigerant supply. A practical system, however, encounters varying heat loads and therefore requires a refrigerant throttling device to prevent starvation or flooding of the evaporator which would seriously affect the evaporator and system efficiency. This variable orifice effect is accomplished by the thermostatic expansion valve which senses evaporator conditions and meters refrigerant to satisfy them. By sensing the temperature and the pressure of the gas leaving the evaporator, the expansion valve precludes the possibility of flooding the evaporator and returning liquid refrigerant to the compressor.

The valve consists of a housing containing an inlet port, an equalizer port, and 25 outlet ports. The flow of refrigerant to the outlet


SENSING BULB
DIAPHRAGM
CAPILLARY TUBE
SPRING
VALVE PIN
POWER HEAD
EQUALIZER PORT
REFRIGERANT FROM EVAPORATOR OUTLET
BODY FLANGE GASKETS
VALVE BODY
OUTLET PORTS (25 PLACES)
TO EVAPORATOR
CAGE ASSEMBLY
POPPET VALVE
SEAT GASKET
LIQUID REFRIGERANT INLET
EVAPORATOR

AM.97

Figure 5-22.—Thermostatic expansion valve.

ports is controlled by positioning a metering valve pin. Valve pin positioning is controlled by the pressure created by the remote sensing bulb in the power section, the superheat spring setting, and the evaporator discharge pressure as supplied by the external equalizer port.

The remote sensing bulb is a closed system and is filled with refrigerant. The bulb itself is placed in a well, attached to the evaporator. The pressure within the bulb corresponds to the pressure of the refrigerant leaving the evaporator. This force is felt on top of the diaphragm in the power head section of the valve, and any increase in pressure will cause the valve to move towards an open position. The bottom side of the diaphragm has the forces of the superheat spring and the external equalizer port pressure acting in a direction to close the valve pin. The valve position at any instant is determined by the resultant of these three forces.

If the temperature of the gas leaving the evaporator increases above the desired superheat value, it will be sensed by the remote bulb. The pressure generated in the bulb is transmitted to the diaphragm in the power section of the valve, causing the valve pin to open. A decrease in the temperature of the gas leaving the evaporator will cause the pressure in the remote bulb to decrease, and the valve pin will move toward the closed position.

The superheat spring is designed to control the amount of superheat in the gas leaving the evaporator. A vapor is said to be superheated when its temperature is higher than that necessary to change it from a liquid to a gas at a certain pressure. This insures that the Freon returning to the compressor is in the gaseous state. The superheat spring is adjustable and is factory set to provide approximately 9 degrees of superheat in this particular vapor cycle system. Superheat setting is calculated in relation to evaporator size and heat loads applied, and should therefore never be tampered with in the field as serious inefficiencies will result.

The equalizer port is provided to compensate for the effect the inherent evaporator pressure drop has on the superheat setting. The equalizer senses evaporator discharge pressure and reflects it back to the power head diaphragm, adjusting the expansion valve pin position to hold the desired superheat value.

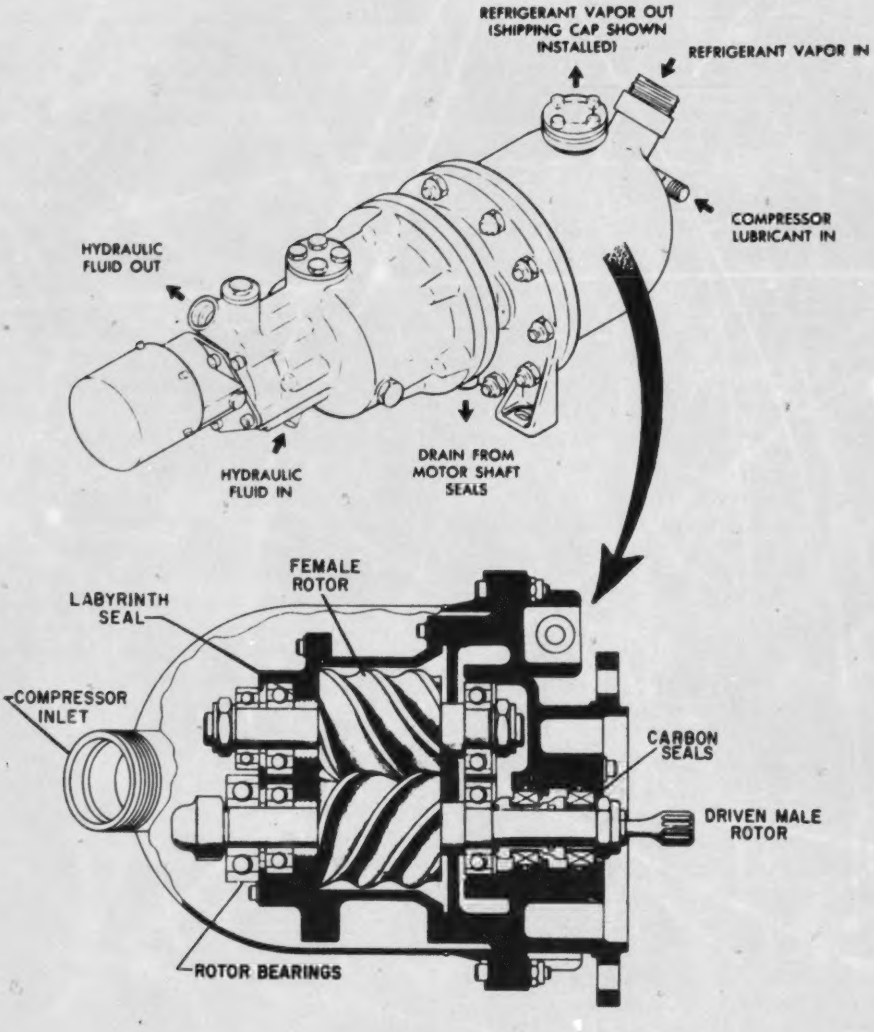
The purpose of the multioutlet configuration of the valve is to insure an even distribution of the refrigerant in the evaporator.

Evaporator

The evaporator (fig. 5-22) is a plate fin heat exchanger forming passages for cooling-air flow and for Freon refrigerant. The evaporator assembly houses a hydraulically driven fan and a low-temperature cutout switch.

When the vapor cycle system is operating, refrigerant from the expansion valve flows into the Freon passages of the evaporator. At the same time, the hydraulically driven fan is forcing air from the electronic equipment compartment across the coils of the evaporator. The air is of a rather high temperature, since it is affected by being circulated through the electronic boxes. This air, in passing through the evaporator, readily gives up its heat to the liquid Freon 12. The Freon is receptive to the heat exchange and, in absorbing the heat, a change of state comes about, changing the Freon from a liquid to a gas at approximately the same temperature that it was changed from a gas to a liquid. Since the Freon compressor is maintaining a constant pressure in the evaporator, the Freon vaporizes at a temperature that causes the air discharging from the evaporator to the electronic compartment to be at approximately 40° F. Vapor leaving the evaporator is also at a temperature of about 40° F.

Attached to the discharge side of the evaporator is a header duct assembly, bolted to the perimeter of the evaporator. This header is used to direct the discharged cooling air to the various distribution ducts. A set of movable louvers in the header is designed to act as a shutoff valve during ground cooling cart operations. During this time an external cart is attached to a receptacle on the right-hand side of the fuselage and feeds to the distribution system for ground operations if desired. This air, however, would also escape in reverse direction through the evaporator and discharge into the forward compartment, thereby reducing the airflow to the electronic equipment. The louvers are actuated by a single control knob located at the top of the header duct. The knob is a two-position control (Open and Close) and is placarded to explain operation. To prevent the louvers from being inadvertently left in the closed position with the possibility of starving the avionics gear of cooling air after ground cart operation has been terminated, an overcenter device is incorporated. This mechanism will automatically open the louvers as soon as


REFRIGERANT VAPOR OUT (SHIPPING CAP SHOWN INSTALLED)
REFRIGERANT VAPOR IN
COMPRESSOR LUBRICANT IN
HYDRAULIC FLUID OUT
HYDRAULIC FLUID IN
DRAIN FROM MOTOR SHAFT SEALS
FEMALE ROTOR
LABYRINTH SEAL
COMPRESSOR INLET
CARBON SEALS
DRIVEN MALE ROTOR
ROTOR BEARINGS

AM.98

Figure 5-23.—Compressor assembly.

a pressure is felt on them from the evaporator fan. The header duct also contains a discharge air filter which filters the recirculated air and also removes the majority of the moisture (if present) in the cooling air on its way to the electronic equipment.

Compressor Assembly

The purpose of the compressor is to evacuate the evaporator, keeping it at a constant pressure, and also to superheat the Freon vapor and feed it to the condenser where it is condensed back into a liquid for reuse. The compressor, shown in figure 5-23, houses two intermeshing helical rotors that rotate in counter-rotating directions. This action causes cool Freon gas to be taken from the evaporator and compressed. This increases its temperature and pressure to a value where it may be fed to the condenser for ambient air to change it back into a liquid. The compressor controls the pressure in the evaporator by varying its speed in response to signals from a suction line pressure switch.

The two intermeshing helical screw type rotors are enclosed in a close tolerance housing, containing an inlet and an outlet port. Since the rotors mesh, they may be distinguished one from the other by calling one the male and the other the female.

The male rotor is directly coupled to, and driven by, a variable speed hydraulic motor. The female rotor is driven aerodynamically by the male. There is no physical contact between the two rotors or between the rotors and case. Inter-rotor contact is prevented by the rotors riding on a film of refrigeration oil. Both rotors are suspended by three pairs of ball bearings, one set on the discharge end and two pairs on the inlet end. Bearing lubrication is supplied by the refrigeration oil. Suitable carbon and labyrinth seals are incorporated to provide control of the flow of lubricating oil. Thin ridges are machined on the ends and flutes of the rotors to seal the mechanism against excessive rotor leakage.

The compressor operates on the principle that if a given volume of gas is trapped and the area in which it is contained gradually decreases, the pressure and temperature of the gas will increase. The counter-rotating rotors are fed a gas charge from the inlet port. This charge fills the gully formed by the rotors. As they rotate, the charge is trapped and forced forward through the housing. The action of the rotors is to decrease the interlobe area in which the charge is contained as they revolve. This increases the pressure and temperature of the refrigerant. As the outlet port is reached, the charge will be contained in the smallest area during its travel through the compressor. It is therefore at its highest temperature and pressure and is discharged into the system.

The variable compressor speed is provided by the governor-controlled, hydraulically driven motor, which responds to electronic impulses from the Freon circuit to increase or decrease speed as demanded by the cooling load.

The electrical wiring of the speed sensing system is such that when the equipment cooling system is shut down, the servomotor will be driven to low speed. This relieves starting loads and also precludes the possibility of an overspeed during startup.

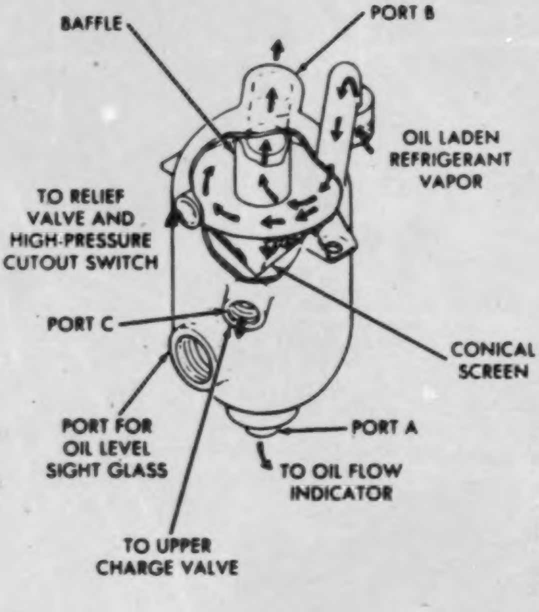
The compressed Freon gas is discharged from the compressor and immediately passes through a check valve which prevents the high-pressure discharge from motorizing the compressor in reverse at system shutdown.

The compressor section requires lubrication; therefore, an oil is mixed with the Freon during system servicing. This oil is also discharged from the compressor outlet and is reclaimed by the oil separator.

Oil Separator

The oil separator (fig. 5-24) is located downstream of the compressor and check valve. It operates on a centrifugal principle; that is, the oil mist refrigerant enters the inlet port of the separator at a tangent to the wall of the cylindrical housing. This imparts a swirling or centrifugal action to the mixture. The centrifugal force has a greater effect on the heavier oil vapors, causing them to collect on the walls and the conical screen. The oil drips from the screen and collects at the bottom of the oil separator.

Oil flows from the bottom of the separator through an oil flow indicator and filter and is injected into the compressor at the shaft seal cavity. The refrigerant vapor rises through the tubular baffle and leaves the separator. A circular sight gage is provided on the separator to


BAFFLE
PORT B
OIL LADEN REFRIGERANT VAPOR
TO RELIEF VALVE AND HIGH-PRESSURE CUTOUT SWITCH
PORT C
CONICAL SCREEN
PORT FOR OIL LEVEL SIGHT GLASS
PORT A
TO OIL FLOW INDICATOR
TO UPPER CHARGE VALVE

AM. 99

Figure 5-24.—Oil separator.

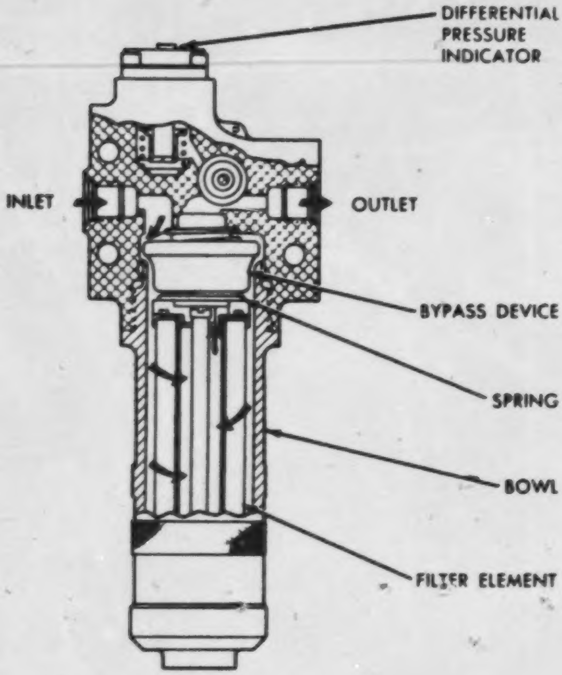
allow for checking the level of system oil during operation, normal oil level being a half full sight gage.

Oil Flow Indicator

The oil flow indicator in the oil return line is basically a metal cage with a sight window. It is used to observe the amount of oil returning to the compressor and to prevent compressor failure when no flow is indicated.

Oil Filter

Oil returning to the compressor passes through a filter which insures a clean oil supply for compressor lubrication. The filter (fig. 5-25) has a replaceable cellulose fiber type element. If the filter becomes clogged, a bypass device permits unfiltered oil to circulate through the compressor when the differential pressure across the filter is greater than 18 to 22 psi.



AM.1139

Figure 5-25.—Oil filter.

When the differential pressure across the filter is greater than 13.5 to 16.5 psi, the red indicator at the top of the filter will pop up and remain extended to provide an indication that the filter requires replacement prior to becoming completely clogged and bypassing contaminant oil to the compressor.

The oil filter is designed with an automatic shutoff feature which permits removal of the filter element and bowl without loss of the refrigerant charge.

Condenser Ejector Shutoff Valve

The condenser ejector shutoff valve is a pneumatically operated valve. It is controlled by a piston through a mechanical linkage. It is spring loaded to the CLOSED position. A solenoid valve on the actuator chamber side of the piston acts as a bleed off for the air being fed from an upstream tap of the valve housing. This air is fed through the hollow piston actuator shaft to the top side of the piston where it is bled off as long as the solenoid is deenergized. Energizing the solenoid closes off the actuator chamber bleed, and pressure builds up. This force overcomes spring tension and the valve opens. Any loss of pneumatic or electrical power to the valve will cause it to assume a closed position.

Charging Valves

There are four back-seating charging valves in the vapor cycle system—three in the evaporator group and one in the condenser group. The valves are used to facilitate servicing of the system as one complete unit or servicing of the evaporator group or condenser group as individual units. The condenser and evaporator group assemblies are equipped with quick-disconnect type refrigerant lines to allow their removal from the aircraft without a loss of refrigerant.

Purge Valves

The refrigerant system is equipped with two purge valves—one at the evaporator group assembly high point and the other on the condenser in the top scoop of the aircraft. The valves are similar to the charge valves. They are used to bleed the system, when required, and for attaching test equipment or the vacuum pump for system evacuation.

MAINTENANCE

Maintenance of the vapor cycle air-conditioning system like the air cycle system, will generally require the joint efforts of personnel from the AME and the AE ratings. Malfunctions of the hydraulic motors which drive the compressor and evaporator fan will require the services of an AMH.

Operational checkout of the vapor cycle system can be accomplished several ways. The AE can perform an operational check of the electrical portion of the system utilizing a Cooling System Test Set, AN/ASM 232 (XN-1), with the engines not running.

Performing an operational check of the complete vapor cycle system without the engines running requires external hydraulic and electrical power and a source of conditioned (cool) air. The cooled air is ducted into the condenser scoop inlet to provide flow through the condenser for condensing the Freon. As was stated earlier, this function is normally accomplished by ram air when sufficient ram-air flow is available or by engine bleed air leaving the ejector nozzles and creating a pressure differential that causes sufficient flow for cooling on the ground when the engines are running.

The operational check steps as specified in the applicable Maintenance Instructions Manual should be performed in sequence. If a trouble occurs during a step, it must be corrected before proceeding. Isolation of the trouble can almost always be enhanced by referring to the step of the troubleshooting table that corresponds with the step of the operational checkout where the trouble occurred. Table 5-2 illustrates a portion of the troubleshooting table utilized when performing an operational check and/or troubleshooting with the engines not running.

Operational check procedures and troubleshooting tables for checking the vapor cycle system and isolating malfunctions with the engines running are also provided in the Maintenance Instructions Manual.

If, during a system operational check, a specific malfunction occurs which is not listed or covered in the accompanying troubleshooting table for that operational check, refer to the general troubleshooting table for the complete vapor cycle system.

The troubles listed in the general troubleshooting table are not numbered and are used to provide supplementary troubleshooting information to cover additional troubles that may occur during the accomplishment of the operational check in any of the methods mentioned (engines running, engines not running, and using test set).

Additional Organizational level maintenance on the vapor cycle system includes servicing (adding refrigerant and lubricating oil), leakage testing and correcting of leaks, and removal and installation of components.

Intermediate level maintenance of the evaporator assembly, the condenser group assembly, and the air ejector shutoff valve is restricted to replacement of parts listed in the Spares and Repair Parts Data List provided in the Intermediate repair section of the applicable Maintenance Instructions Manual (Part IV). Special test equipment is required to bench test most of the vapor cycle components or assemblies and therefore not all Intermediate level activities possess the capability to accomplish such maintenance.

Since proper servicing of the vapor cycle system is one of the most important factors affecting operation, equipment used for servicing and servicing procedures are given brief coverage in the following paragraphs.

Servicing Equipment

Servicing of the vapor cycle system involves evacuating and charging of the condenser and evaporator group assemblies either separately or preferably together as a system, with refrigerant and/or lubricating oil.

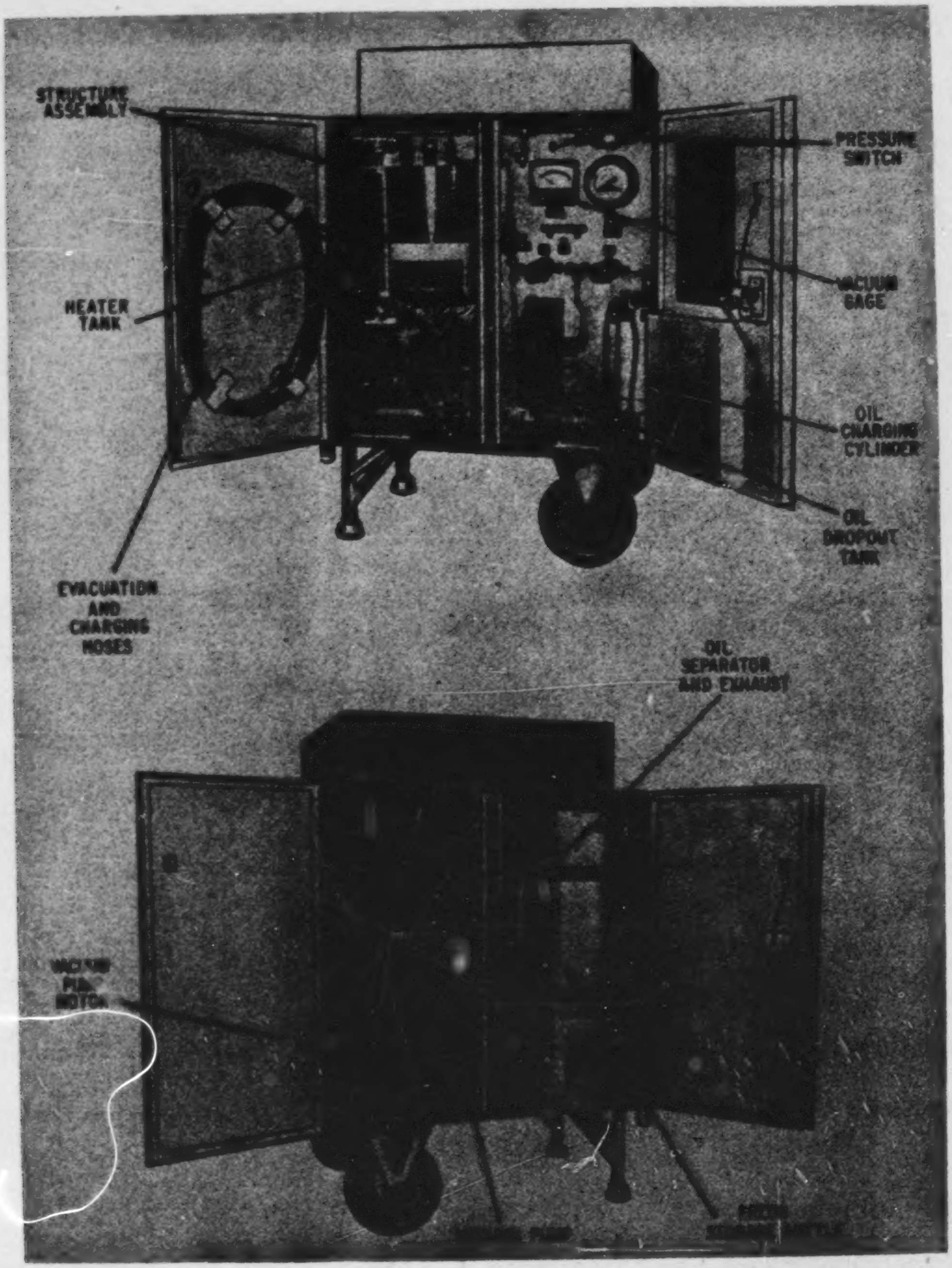
The Vapor Cycle Charging Cart (fig. 5-26) is used to replenish the vapor cycle refrigeration system with refrigerant and the compressor with lubricating oil. The major components of the cart are labeled in figure 5-26. Table 5-3 provides a complete list of the operating controls and indicators shown on the front view of the cart (fig. 5-27).

The Freon storage bottle has a capacity of 25 pounds of Freon. The bottle is restrained in the cart by quick-release restraining straps which permit rapid removal and replacement of depleted bottles.

The electric-motor-driven vacuum pump is used to evacuate a refrigerant system prior to recharging it with Freon. Evacuating or pulling a vacuum on the system for a short period of time causes any moisture in the system to be vaporized and withdrawn from the system. Moisture in the system, if of sufficient quantity, can freeze at the expansion valve, thus allowing no Freon into the evaporator and cooling would stop.

Table 5-2.—Troubleshooting vapor cycle system (engines not running).

Probable cause	Isolation procedure	Remedy
STEP 17 TROUBLE: BUBBLES AND/OR FOAM IN REFRIGERANT SIGHT GLASS		
Inadequate charge.	Add refrigerant to system. Refer to paragraph 3-389.	If sight glass does not clear up with proper charge, proceed to next probable cause.
Fittings, tube assemblies, and components.	Check all fittings, tube assemblies, and components for presence of oil, indicating refrigerant leakage.	Correct leak and add refrigerant to system. Refer to paragraph 3-389.
STEP 20 TROUBLE: NO POSITIVE FLOW OF COMPRESSOR OIL		
Insufficient oil in system.	Add oil to system. Refer to paragraph 3-390.	If positive flow of oil is obtained, proceed to step 21 of checkout procedure.
Fittings, tube assemblies and components.	Check all fittings, tube assemblies and components for presence of oil.	Correct leak and add oil to system. Refer to paragraph 3-390.
STEP 22 TROUBLE: NO VAPOR CYCLE PRESSURE		
Evaporator fan inoperative.	Check return airflow at discharge duct on left hand forward side of STA 356 bulkhead.	If no airflow is present, refer to step 17 trouble. EVAPORATOR FAN DOES NOT OPERATE.
Pressure indicator.	Check pressure pick up and plumbing for security, cleanliness, and damage.	Repair or replace as required.
	Replace pressure gage with one known to operate properly.	If trouble is corrected, forward defective component to next higher maintenance level.
Header damper valve.	Check damper valve handle position.	If knob is in aft position (used for external cart cooling) and fan is operating, replace header assembly. Refer to paragraph 3-402.
Evaporator passages.	Check for blockage of evaporator passages.	Remove obstruction.
Air distribution ducting defective or improperly installed.	Check ducting for proper installation and condition.	Repair or replace defective components as required.
STEP 22 TROUBLE: VAPOR CYCLE PRESSURE GAGE INDICATING IN YELLOW ARC		
Insufficient hydraulic flow from external source.	Check for 3,000 psi at 25 gpm output from hydraulic unit.	Adjust hydraulic power supply.


STRUCTURE ASSEMBLY
PRESSURE SWITCH
HEATER TANK
VACUUM GAGE
OIL CHARGING CYLINDER
OIL DROPOUT TANK
EVACUATION AND CHARGING HOSES
OIL SEPARATOR AND EXHAUST
VACUUM PUMP MOTOR
VACUUM PUMP
FREON STORAGE BOTTLE

AM.1140

Figure 5-26.—Vapor cycle charging cart.

Table 5-3.—Operating controls and indicators.

Figure 5-27 Index No.	Control or indicator	Function
1	Flow control valve.	Prevents vaporized Freon from entering the charging line.
2	Vacuum lamp (amber).	Illuminates to indicate vacuum system is operating.
3	Bleeder valve.	When open, exhausts Freon vapor in the heater tank to atmosphere.
4	Vacuum gage.	Indicates amount of vacuum pressure in system.
5	VACUUM-OFF-HEATER switch.	Controls vacuum and heater circuits.
6	Heater lamp (red).	Illuminates to indicate heater system is on.
7	Freon tank pressure gage.	Indicates pressure in the Freon heater tank.
8	Flow control valve.	When open, allows gage tube to sense vacuum in the system for readout at vacuum gage (4).
9	Oil charging pressure gage.	Indicates pressure in oil charging cylinder.
10	Bleeder valve.	When open, relieves pressure in the oil charging cylinder.
11	Shutoff valve.	When open, allows a flow of Ansul 150 oil through the charging hose.
12	Drain valve.	Allows drainage of oil from the oil dropout tank.
13	Flow control valve.	Opens the vacuum line from flow control valve (14) to vacuum pump.
14	Flow control valve.	Permits flow from unit being evacuated.
15	Flow control valve.	Controls flow of Freon from heater tank to charging hose.
16	Flow control valve.	Controls flow of Freon from refrigerant storage bottle to the heater tank.
17	Freon liquid level sight gage.	Indicates level of Freon in the heater tank.

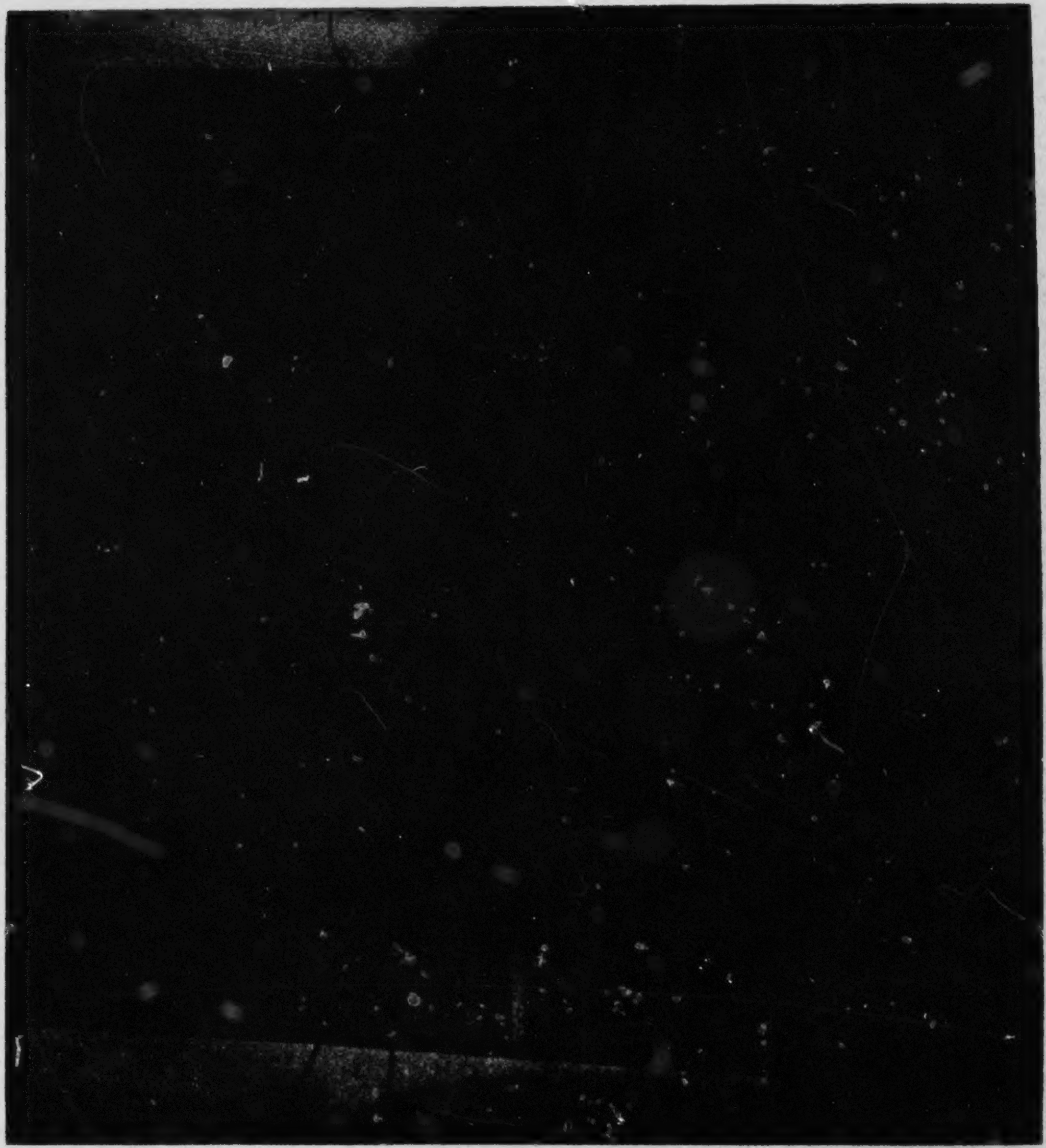


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Figure 5-27.—Servicing cart—controls and indicators.

The vacuum pump has a displacement of 3 cubic feet per minute (cfm) and is rated for continuous duty.

The heater tank has a capacity of 360 cubic inches and an operating pressure rating of 200 psi at 125°F. A liquid level sight gage, mounted vertically on the heater tank, indicates the level of liquid Freon in the tank. A scale, graduated in pounds and ounces, is mounted alongside the sight gage and ranges from 0 to 17 pounds. The tank is also equipped with a compound pressure gage which is graduated from 0 to 30 inches Hg (mercury vacuum) and 0 to 300 psi pressure. A heating blanket surrounds the heater tank and is used to heat the refrigerant for building up tank pressure sufficient for charging a system.

The oil charging cylinder stores Ansul 150 lubricating oil used to replenish the vapor cycle compressor oil supply. The cylinder has a capacity of 68 cubic inches and an operating pressure of 100 psi at 125° F. The cylinder is equipped with an oil level sight gage and an oil charging pressure gage. A scale, graduated in centimeters, is mounted beside the sight gage and ranges from 0 to 800 cc.

The flexible evacuation and charging hoses are both 180 inches long to accommodate hooking the cart to the unit being evacuated or charged without removing the unit from the aircraft.

An aircraft power cable connects primary electrical power from the cart to the aircraft. A deck edge power cable or power cable from electric generating equipment such as the NC-5 provides power to the cart.

NOTE: In addition to the controls and indicators listed in table 5-3, a circuit breaker is located in the back left-hand side of the cart to provide overload protection for the cart electrical system. A shutoff valve on the bottom end of the Freon storage bottle (fig. 5-26) is utilized to allow a flow of liquid Freon from the storage bottle to the heater tank or charging lines.

Servicing/Charging

Whenever any unit in the refrigerant system is disconnected, the compressor oil filter should be checked for contamination. If contaminated, the filter element should be replaced.

Removal of components in the system will first require that refrigerant be depleted from the system or group assembly. The refrigerant is depleted in the following manner:

1. Remove the cap from the upper charge valve of the evaporator group assembly.
2. Connect a flexible hose to the charge valve and place the opposite end in a well-ventilated area where it will not constitute a hazard to personnel.

WARNING: Appropriate eye protection should be worn and skin contact with the refrigerant should be avoided.

3. Remove the safety plug from the charge valve.
4. Slowly unscrew the bleeder plug in a counterclockwise direction and deplete system pressure.

As was previously stated, the preferred method for charging the vapor cycle system is as a complete unit. Charging of the evaporator or condenser group as individual units is possible. Due to the similarity in charging the individual units and charging the complete vapor cycle system, coverage in this section will be limited to charging of the complete system which is accomplished as follows:

1. Connect one end of a flexible hose to the upper charge valve of the evaporator group assembly and the other end in a suitable container for accepting refrigerant.
2. Open the charge valve and permit refrigerant to slowly drain from the system. When draining is completed, remove the draining hose.
3. Position the vapor cycle charging cart near the aircraft and connect the evacuation hose to the upper charge valve and start the cart vacuum pump. The vacuum pump is started by placing the VACUUM-OFF-HEATER switch (table 5-3, item 5 and fig. 5-27) to the vacuum position with valves 8, 13, and 14 open and all other valves closed.
4. Permit the vacuum pump to run until a vacuum of 1.0 cm of mercury is indicated on the cart vacuum gage (4). This will normally require about 30 minutes of pumping.
5. When the correct vacuum is achieved, close the upper charge valve, then shut off the vacuum pump and disconnect the evacuation hose.
6. Fill the servicing cart refrigerant pressure cylinder (heater tank) to the 15-pound level mark on the liquid sight gage. This is accomplished by opening the Freon storage bottle shutoff valve and the bleeder valve (3). The bleeder valve is opened to allow displacement of air in the heater tank. The Freon in a liquid state in the storage bottle is under pressure and will easily flow into the heater tank.
7. Connect the cart pressure cylinder supply hose to the lower charge valve on the evaporator group assembly, but do not tighten the coupling.
8. Actuate the heater switch (5) on the servicing cart. Allow the heater to remain ON until 100 psi is indicated on the tank pressure gage (7).
9. Open the cart refrigerant control valve (15). Loosen the coupling on the lower charge

valve so that refrigerant will displace air trapped in the charging hose, then tighten the coupling.

10. Open the lower charging valve and charge the complete vapor cycle system with 12 pounds of refrigerant as indicated by the scale beside the liquid sight gage.

11. Close the charge valve and the servicing cart refrigerant control valve (15). Disconnect the charging hose and store it in the cart.

12. Start the vapor cycle system and place the MODE SELECTOR switch in MAN position. Hold the MANUAL TEMP CONT switch in the DEC position for 35 seconds.

13. Check the oil flow indicator for a positive flow of oil which would indicate an adequate oil charge.

14. Reset the MODE SELECTOR switch to the AUTO position and shut off the vapor cycle system.

ADDING REFRIGERANT.—If a refrigerant system is merely low on Freon caused by a leak which has been corrected, it can be topped off or added to in the following manner:

1. With the servicing cart connected to the aircraft in the same manner as was previously described for charging the complete system and the vapor cycle system ON, open the lower charge valve and admit small quantities of refrigerant into the system, using the charging cylinder valve (15) to meter the flow. When bubbles in the refrigerant sight glass have cleared, add one additional pound of freon and close the charge valve.

2. Close the charging cylinder valve and disconnect the charging hose and store it in the cart.

3. Reset the MODE SELECTOR switch to the AUTO position as before and then shut off the vapor cycle system.

ADDING LUBRICATING OIL.— If the liquid level sight gage on the oil reservoir indicates that lubricating oil is low, it may be added in the following manner:

1. Fill the servicing cart oil charging cylinder with 700 cc of Ansul 150 lubricating oil. Pressurize the cylinder by connecting it to the Freon charging system of the cart and opening valve (1) until the oil charging cylinder pressure gage reads 85 psi.

2. Start the vapor cycle system (this is always accomplished following the specific instructions provided in the Maintenance Instructions Manual).

3. Connect the supply hose from the oil charging cylinder to the lower charging valve on the evaporator group. Do not tighten the coupling. Open the oil cylinder supply line and purge the supply hose until oil escapes from the coupling, then tighten the coupling.

4. Place the MODE SELECTOR switch in MAN position and hold the MANUAL TEMP CONT switch in DEC position for 35 seconds. This will increase the speed of the refrigerant compressor.

5. Open the lower charge valve and let oil flow into the system until the oil level is in the top quarter of the oil reservoir sight glass. Close the charge valve and shut off the oil cylinder. Disconnect the hose from the charge valve and store the cylinder in the service cart.

6. Reset the MODE SELECTOR switch to the AUTO position and shut off the vapor cycle system.

SAFETY PRECAUTIONS

To prevent injury to personnel and damage to equipment, the following safety precautions and handling procedures should be observed when working with Freon:

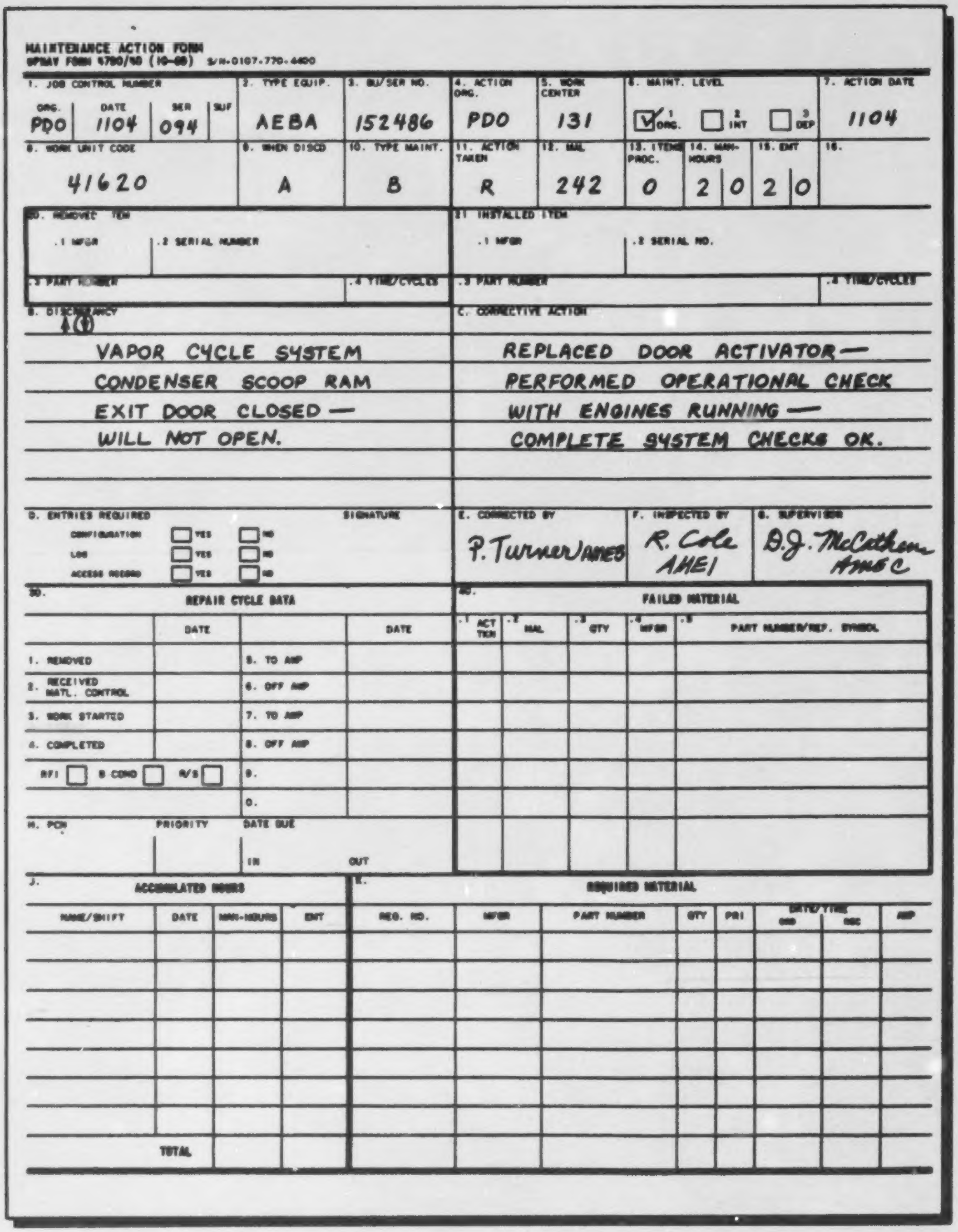
1. When handling Freon, protective equipment (apron, gloves, goggles, and face mask) must be worn.

2. If liquid Freon comes in contact with the skin, treat the skin for frostbite.

3. If liquid Freon comes in contact with the eyes, medical attention must be sought immediately. The following first aid treatment should be administered: Do not rub or irritate the eyes; drop sterile mineral oil into the eyes; then wash the eyes with a boric acid solution if the irritation continues.

4. Freon is stored in cylinders that are color coded orange with appropriate lettering for identification. These cylinders should be handled carefully because the pressure inside the cylinder depends upon the ambient temperature. Refrigerant cylinders should not be exposed to high temperatures or flames. Cylinders that are used for high-pressure liquids should never the thrown around, dropped, or used for anything other than their intended purpose. Refrigerant cylinders should never be filled to more than 85 percent of their capacity.

5. Freon tends to dissolve natural rubber; therefore, only the recommended gaskets, O-rings, and packings should be used in the vapor cycle system.



MAINTENANCE ACTION FORM
OPNAV FORM 4790/60 (10-68) S/N-0107-770-4400

1. JOB CONTROL NUMBER ORG. PDO	DATE 1104	SER 094	SUF	2. TYPE EQUIP. AEBA	3. BU/SER NO. 152486	4. ACTION ORG. PDO	5. WORK CENTER 131	6. MAINT. LEVEL ☑ 1 ORG. ☐ 2 INT ☐ 3 DEP	7. ACTION DATE 1104

8. WORK UNIT CODE 41620	9. WHEN DISCD A	10. TYPE MAINT. B	11. ACTION TAKEN R	12. MAL 242	13. ITEMS PROC. 0	14. MAN-HOURS 2 0	15. EMT 2 0	16.

20. REMOVED ITEM
.1 MFGR
.2 SERIAL NUMBER
.3 PART NUMBER
.4 TIME/CYCLES

21 INSTALLED ITEM
.1 MFGR
.2 SERIAL NO.
.3 PART NUMBER
.4 TIME/CYCLES

B. DISCREPANCY

VAPOR CYCLE SYSTEM
CONDENSER SCOOP RAM
EXIT DOOR CLOSED —
WILL NOT OPEN.

C. CORRECTIVE ACTION

REPLACED DOOR ACTIVATOR —
PERFORMED OPERATIONAL CHECK
WITH ENGINES RUNNING —
COMPLETE SYSTEM CHECKS OK.

D. ENTRIES REQUIRED SIGNATURE
CONFIGURATION ☐ YES ☐ NO
LOG ☐ YES ☐ NO
ACCESS RECORD ☐ YES ☐ NO

E. CORRECTED BY P. Turner AMES
F. INSPECTED BY R. Cole AMEI
G. SUPERVISOR D.J. McCathern AMSC

30. REPAIR CYCLE DATA

	DATE		DATE
1. REMOVED		5. TO AWP	
2. RECEIVED MATL. CONTROL		6. OFF AWP	
3. WORK STARTED		7. TO AWP	
4. COMPLETED		8. OFF AWP	
RFI ☐ B COND ☐ A/S ☐		9.	
		0.	

H. PCN
PRIORITY
DATE DUE IN OUT

40. FAILED MATERIAL

.1 ACT TKN	.2 MAL	.3 QTY	.4 MFGR	.5 PART NUMBER/REF. SYMBOL

J. ACCUMULATED HOURS

NAME/SHIFT	DATE	MAN-HOURS	EMT
TOTAL			

K. REQUIRED MATERIAL

REQ. NO.	MFGR	PART NUMBER	QTY	PRI	DATE/TIME ORD	DATE/TIME REC	AWP

AM. 1142

Figure 5-28.—Documenting an assist maintenance action.

MAINTENANCE DOCUMENTATION BY AN ASSISTING WORK CENTER

Malfunctions of the air-conditioning system could be of an electrical or mechanical nature or, in the case of the vapor cycle system covered in this chapter, it could be electrical, mechanical, or hydraulic. When isolation and correction of a malfunction requires the services of more than one rating and/or work center, the work center that the discrepancy is most likely to concern is designated the primary work center. Any other work centers which are involved in either the isolation or correction (or both) of the discrepancy is designated as the assisting work center.

The assisting work center will account for its manhours utilizing a single copy Maintenance Action Form (MAF). Figure 5-28 provides an example of a single copy MAF originated by an AME assigned to work center 131 who provided assistance to the activity's electric shop in performing an operational check of the vapor cycle system and correcting a discrepancy.

The data elements on the MAF turned in by the assisting work center will match those on the MAF turned in by the primary work center except as follows: Block 5 will reflect the assisting work center's code, block 13 will show 0 items processed, and blocks 14 and 15 will reflect the manhours and elapsed maintenance time actually used in assisting the primary work center.

Block 7, the action date, may or may not differ since it reflects the date of completion of the assistance and not the correction of the primary discrepancy.

No entries will appear in blocks 20, 21, 31, or 40.

The narrative description and corrective action may or may not be the same as that of the primary work center.

Complete information for documenting maintenance actions is provided in Military Requirements for Petty Officer 3 & 2, NavPers 10056-C, and OpNav Instruction 4790.2 (Series).

CHAPTER 6

UTILITY SYSTEMS

The utility systems of an aircraft provide an additional measure of flight safety, pilot comfort and convenience, and contribute to the overall mission capabilities of the aircraft. Those utility systems of primary concern to the AME and included in this chapter are the various auxiliary bleed-air systems, fire extinguishing systems, life raft ejection systems, coolanol type liquid coolant systems, and thermal radiation protection systems.

AUXILIARY BLEED-AIR SYSTEMS

In addition to being used for pressurizing and air conditioning the cockpit and electronic equipment compartments, jet engine bleed air is used for a number of other purposes. Among these uses are the defrost/defogging of the canopy and windshield; windshield washing, anti-icing, and rain removal; inflation of the canopy seal; pressurizing of the pilot's anti-g suit; pressurizing of fuel tanks and hydraulic reservoirs; and wing and tail leading edge deicing/anti-icing. These systems are all generally referred to as auxiliary bleed-air systems.

These systems are tapped into the cockpit/cabin air-conditioning and pressurization system; however, each auxiliary system has its own controls for turning air off and on, limiting pressure, etc. Figure 5-1 provides an example of a typical air-conditioning and pressurization system. Note the variety of auxiliary bleed-air systems tapped off the system ducting at various points and the auxiliary bleed-air system controls located on the master air-conditioning panel. Bleed-air controls on this panel include the defog airflow thumbwheel control, anti-icing, windshield washing, and rain removal controls. These auxiliary systems are typical of those found on most carrier type aircraft. Several individual systems and associated components are described and illustrated in this chapter.

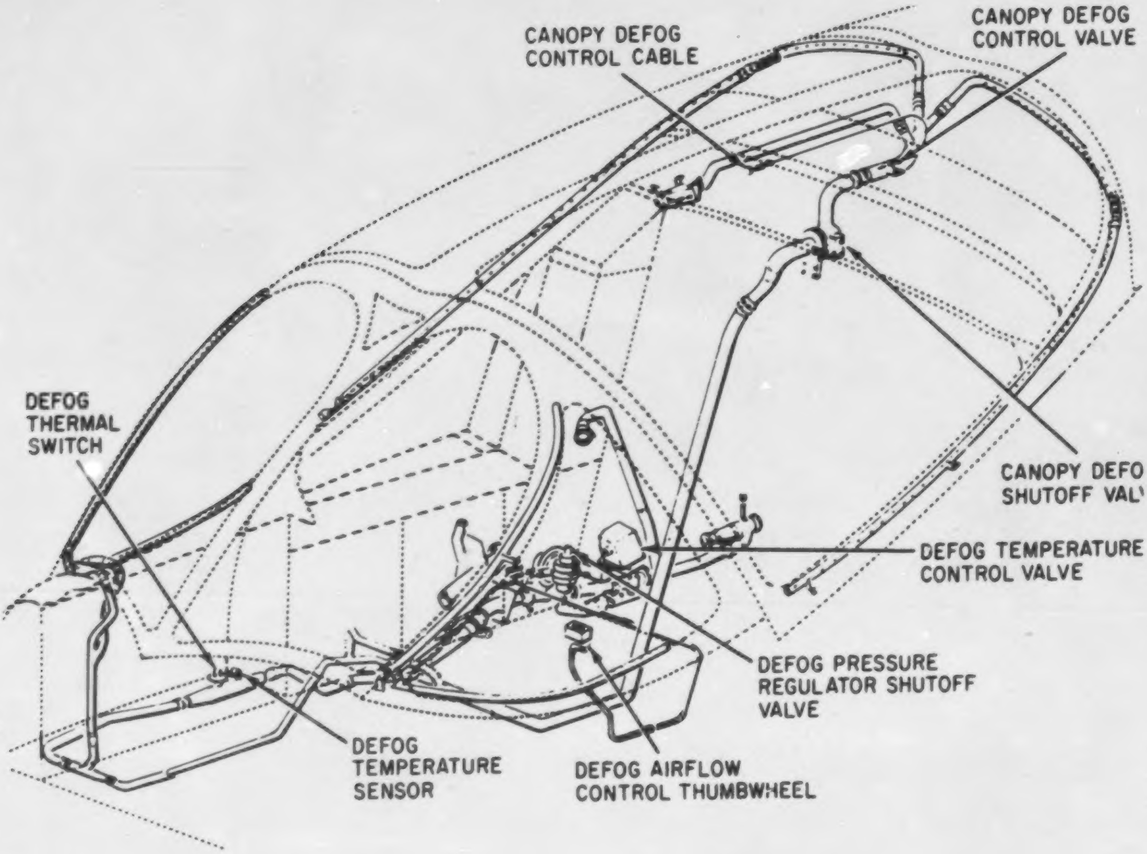
DEFROST/DEFOGGING SYSTEMS

A typical defrosting/defogging system installation is shown in figure 6-1. The bleed air supplied to the defog outlets (diffusers) is a pressure regulated and temperature controlled mixture of direct engine bleed air and bleed air that has been slightly cooled by passing through the main section of the ram air heat exchanger. (See fig. 5-1, ch. 5.) The pressure of the defogging system air is regulated by the action of the defog pressure regulator-shutoff valve.

Cockpit controls consist of the defog airflow control thumbwheel. (See the master air-conditioning control panel fig. 5-1.) The thumbwheel shuts the defog system off and on by closing or opening the butterfly valve of the pressure regulator-shutoff valve and controls the pressure (airflow) of the defog air within the limits of the valve.

Moving the thumbwheel from the OFF position to position setting 1 turns the system ON. Further movement of the thumbwheel in the clockwise direction to a higher setting (numbered 1 through 14) increases the flow of defog air through the pressure regulator-shutoff valve.

A temperature sensor, high limit switch, temperature control valve, and electrical temperature controller operate to automatically maintain the temperature of defog airflow supplied to the canopy and windshield diffusers at approximately 240° F. This temperature control is basically achieved by the defog and equipment cooling temperature controller, causing the defog temperature control valve to cycle from open to close. Cycling of the temperature control valve regulates the flow of engine bleed air going to the supply lines and mixing with the


CANOPY DEFOG
CONTROL CABLE
CANOPY DEFOG
CONTROL VALVE
DEFOG
THERMAL
SWITCH
CANOPY DEFO
SHUTOFF VAL
DEFOG TEMPERATURE
CONTROL VALVE
DEFOG PRESSURE
REGULATOR SHUTOFF
VALVE
DEFOG
TEMPERATURE
SENSOR
DEFOG AIRFLOW
CONTROL THUMBWHEEL

AM.1143

Figure 6-1.—Defogging system.

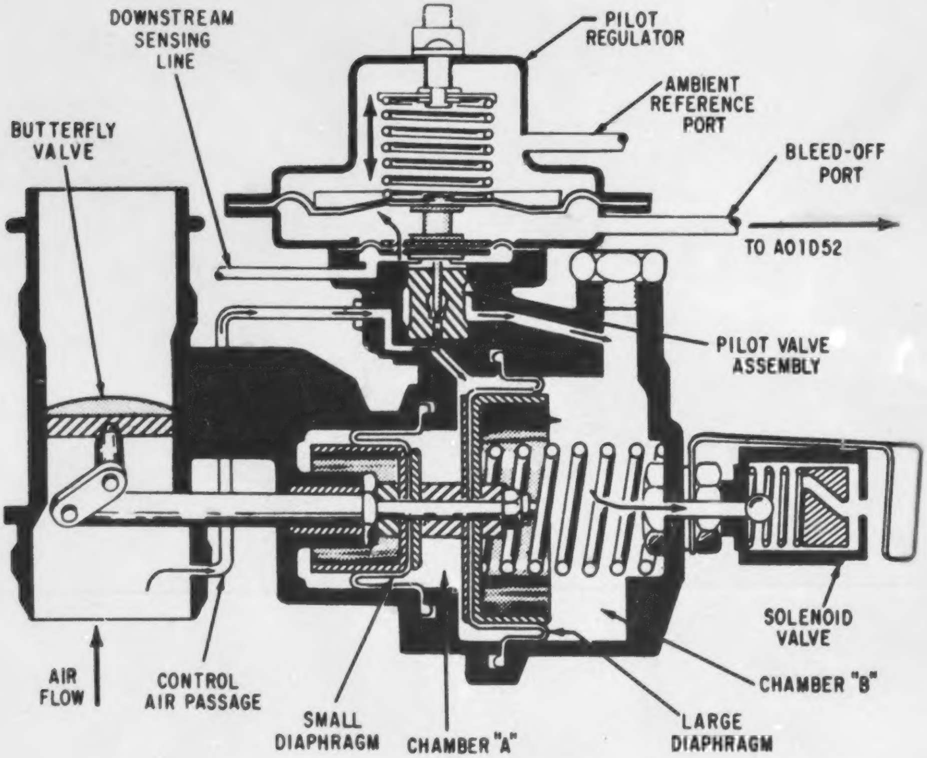
partially cooled air flowing from the main section of the ram air heat exchanger. (See fig. 5-1.)

Defog Pressure Regulator-Shutoff Valve

The defog pressure regulator-shutoff valve illustrated in figure 6-2 is pneumatically operated and solenoid controlled. When the DEFOG AIRFLOW thumbwheel is in the OFF position, the solenoid is deenergized. Air from the upstream side of the butterfly valve passes through the control air passage to chamber "A" and past the pilot valve assembly to chamber "B." With equalized pressure on both sides of the large diaphragm, the pressure on the smaller diaphragm and the spring force against the large diaphragm combine to close the butterfly valve and/or hold it closed.

Energizing of the solenoid by moving the thumbwheel from OFF to position 1, bleeds air from chamber "B" through the solenoid, and air pressure acting on the chamber "A" side of the large diaphragm causes the butterfly valve to open.

As the valve opens, downstream air is applied through the downstream pressure sensing line to the bottom side of the pilot regulator diaphragm. The regulator valve stem unseats and permits upstream control airflow to chamber "B". As the airflow thumbwheel is turned clockwise to higher numbered settings, less pressure is felt at the bottom of the pilot


DOWNSTREAM SENSING LINE
PILOT REGULATOR
AMBIENT REFERENCE PORT
BUTTERFLY VALVE
BLEED-OFF PORT
TO A01D52
PILOT VALVE ASSEMBLY
SOLENOID VALVE
AIR FLOW
CONTROL AIR PASSAGE
CHAMBER "B"
SMALL DIAPHRAGM
CHAMBER "A"
LARGE DIAPHRAGM

AM.1144

Figure 6-2.—Defog pressure regulator-shutoff valve.

regulator diaphragm. Consequently, the regulator valve stem is lowered into the pilot valve assembly, restricting airflow to chamber "B" and increasing the pressure in chamber "A." This causes the butterfly valve to open further, increasing the airflow through the valve.

If downstream duct pressure exceeds the values of the regulator setting, the pilot valve would open fully and, since the opening in the solenoid valve is small, it would not be capable of bleeding off the increased airflow into chamber "B." The buildup of air pressure in chamber "B" would move the butterfly valve towards the closed position until pressure is reduced to within regulation limits.

Defog Temperature Control Valve

The defog system temperature control valve is similar to the air-conditioning system shutoff and temperature control valves covered in chapter 5, and therefore no additional coverage is provided in this chapter. As previously stated, the valve operates in response to electrical signals from the defog and equipment (electronic) cooling temperature controller.

Canopy Defog Shutoff Valve

The canopy defog shutoff valve (fig. 6-1) is a simple mechanically actuated spring-loaded butterfly valve. The body of the valve forms a part of the defog diffuser ducting. As the canopy is closed, a lever, which is rigidly connected to the butterfly valve, is aligned with a striker mounted on the aft end of the canopy center beam. The striker moves the lever to open the butterfly valve and allow defog airflow to the canopy diffusers. When the canopy opens, spring tension closes the butterfly valve and blocks the airflow.

Canopy Defog Control Valve

The canopy defog control valve (fig. 6-1) is a manually operated butterfly valve located aft of the canopy shutoff valve in the inlet ducting to the canopy diffusers. The valve is manually controlled by a cable-connected actuating lever located on the canopy overhead center beam. This valve provides a means of manually controlling the defog airflow through the canopy diffusers. Partial closing of this valve will direct a larger portion of available defog airflow to the windshield diffusers to provide a more rapid defogging/defrosting action. A rapid change in altitude and subsequent outside air temperature surrounding the aircraft could frost or fog the windshield and/or canopy and present a flight hazard. Since directional vision through the windshield is generally more important than side vision through the canopy during altitude changes, it may be desirable or necessary to insure that the windshield receive some priority of defrosting/defogging airflow.

WINDSHIELD WASHING, ANTI-ICING, AND RAIN REMOVAL SYSTEMS

Aircraft windshield washing, anti-icing, and rain removal systems are designed to wash, dry, and deice the pilot's and copilot's windshield or windscreen. On aircraft with a side by side seating arrangement to accommodate a pilot and copilot, both windshield panels are washed, dried, and kept clear of rain. On dual arrangements where the right seat is occupied by a radar intelligence officer, bombardier navigator, observer, etc., the right windshield panel may or may not be serviced by such a system.

Figure 6-3 provides a schematic of a typical windshield washing and rain removal system where washing, drying, and rain removal are provided only to the pilot's windshield panel. The system is controlled by the three-position switch located on the master air-conditioning panel.

When the switch is placed at the WASH position, the windshield washing valve solenoid is energized and the valve directs pressure regulated partially cooled air from the aircraft's air-conditioning and pressurization system auxiliary heat exchanger to the windshield washing tank. The tank contains a mixture of 50% methyl alcohol and 50% water. Pressure forces this mixture from the tank through the windshield washing nozzles and onto the left-hand windshield panel.

Placing the windshield switch at the AIR position energizes the solenoid of the rain removal pressure regulator-shutoff valve. The valve opens to allow hot engine bleed airflow through the valve to the rain removal nozzle assembly. Figure 6-4 shows the windshield wash and rain removal nozzle installation and the manner in which hot engine bleed air is mixed with ambient air and directed at the windshield panel.

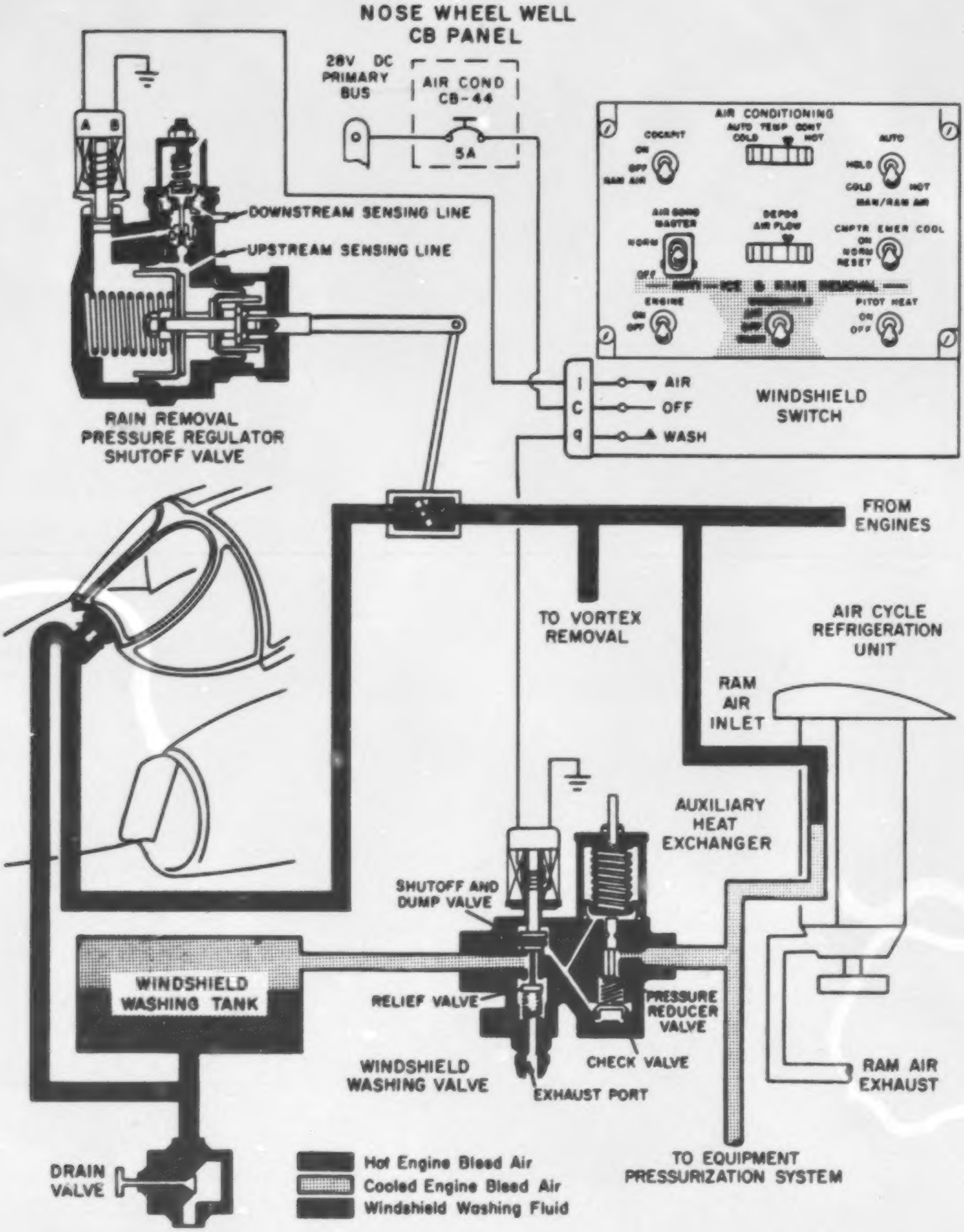
The pressure regulated bleed air discharging from the ejector nozzle into the ejector passage creates a suction or low-pressure area. Ambient air is drawn into the ejector, mixed with the bleed air, and then forced into the plenum chamber where it is distributed to the nozzles that direct the partially cooled (still hot) air in a wide stream across the entire windshield panel. The plenum chamber provides an approximately equal pressure to each nozzle. The temperature of the the air exiting from the nozzles will vary, depending upon engine speed and outside air temperatures.

Windshield Washing Valve

The windshield washing valve (fig. 6-3) controls the air pressure to the windshield washing fluid tank. It is a combination valve, providing pressure regulation, shutoff and dumping, check valve, and relief valve features.

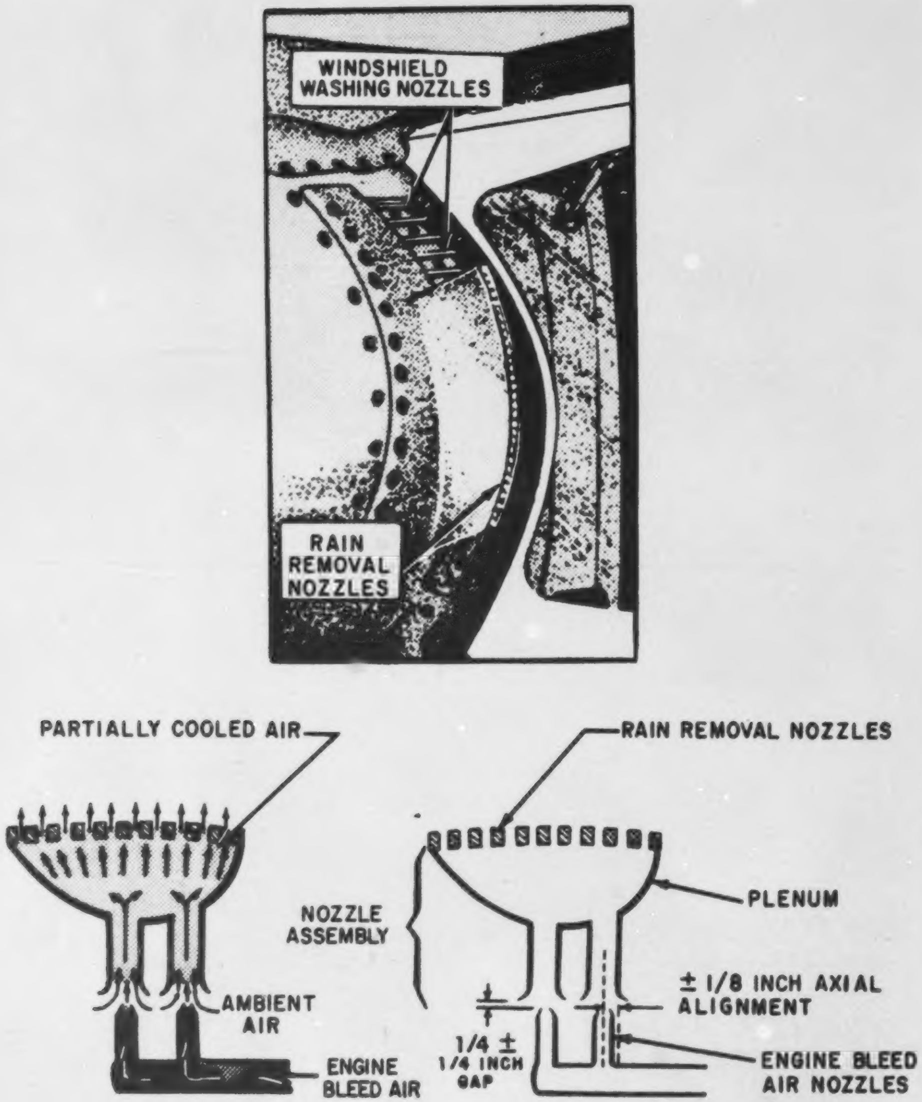
When the valve solenoid is deenergized, the inlet port is sealed from the outlet port, and the outlet port is open to the exhaust port. When the shutoff valve is seated, the linkage pin between the shutoff valve and the relief valve holds the relief valve off its seat, venting the tank to ambient. Therefore, in the deenergized position, the valve is performing the functions of a shutoff valve and dump valve.

Energizing the solenoid (windshield switch in the WASH position) opens the shutoff valve and seats the relief valve. Partially cooled bleed air passes through the pressure reducer valve and the check valve and out the outlet port. Pressure buildup in the passage from the check valve to the shutoff valve section acts upon the pressure regulating diaphragm. The diaphragm rises as the pressure builds, slowly


NOSE WHEEL WELL
CB PANEL
28V DC
PRIMARY
BUS
AIR COND
CB-44
5A
A
B
DOWNSTREAM SENSING LINE
UPSTREAM SENSING LINE
RAIN REMOVAL
PRESSURE REGULATOR
SHUTOFF VALVE
AIR CONDITIONING
AUTO TEMP CONT
COLD
HOT
COCKPIT
ON
OFF
RAM AIR
AUTO
HOLD
COLD
HOT
MAN/RAM AIR
AIR COND
MASTER
NORM
OFF
DEFOG
AIR FLOW
CMPTR EMER COOL
ON
NORM
RESET
ANTI-ICE & RAIN REMOVAL
ENGINE
ON
OFF
WINDSHIELD
AIR
OFF
WASH
PITOT HEAT
ON
OFF
I
C
q
AIR
OFF
WASH
WINDSHIELD
SWITCH
FROM
ENGINES
TO VORTEX
REMOVAL
AIR CYCLE
REFRIGERATION
UNIT
RAM
AIR
INLET
AUXILIARY
HEAT
EXCHANGER
SHUTOFF AND
DUMP VALVE
WINDSHIELD
WASHING TANK
RELIEF VALVE
PRESSURE
REDUCER
VALVE
CHECK VALVE
WINDSHIELD
WASHING VALVE
EXHAUST PORT
RAM AIR
EXHAUST
DRAIN
VALVE
Hot Engine Bleed Air
Cooled Engine Bleed Air
Windshield Washing Fluid
TO EQUIPMENT
PRESSURIZATION SYSTEM

AM.1145

Figure 6-3.—Windshield washing and rain removal system.


WINDSHIELD WASHING NOZZLES
RAIN REMOVAL NOZZLES
PARTIALLY COOLED AIR
AMBIENT AIR
ENGINE BLEED AIR
RAIN REMOVAL NOZZLES
NOZZLE ASSEMBLY
PLENUM
± 1/8 INCH AXIAL ALIGNMENT
1/4 ± 1/4 INCH GAP
ENGINE BLEED AIR NOZZLES

AM.1146

Figure 6-4.—Windshield wash and rain removal nozzles.

reducing the opening of the pressure reducer valve until the pressure at the outlet port stabilizes at approximately 9 to 10 psi.

If the pressure in the washing tank exceeds approximately 13 psi, the relief valve will open to keep the tank pressure within safe limits. The check valve in the windshield washing valve prevents washing fluid from flowing back through the pressure reducer valve. This could occur if inlet pressure drops below tank and outlet pressure.

Outlet air pressure can be adjusted externally by loosening the locknut and turning the screw to adjust the spring tension against the pressure reducer valve. Turning the screw clockwise increases the outlet pressure. Counterclockwise movement reduces the outlet pressure. When adjusting pressure, the outlet line to the tank should be disconnected and a pressure gage installed in the outlet port.

Rain Removal Pressure Regulator-Shutoff Valve

This pneumatically operated, solenoid controlled valve regulates outlet bleed-air pressure at the valve to approximately 76 psi. While the physical appearance of the valve is slightly different than the defog pressure regulator-shutoff valve (fig. 6-2), the principle of operation of the two valves is identical and no further coverage is provided.

CANOPY SEAL SYSTEMS

On most pressurized aircraft, provisions are made for sealing the canopy by making use of engine bleed air to inflate a rubber tube which forms a pressure-tight seal between the canopy and the fuselage. Initiation of seal inflation and deflation is caused by mechanical, electrical, or hydraulic means. An electrically controlled and a mechanical/hydraulic controlled system will be covered in this section.

Electrically Controlled Canopy Seal System

A typical electrically controlled canopy seal system installation is illustrated in figure 6-5.

An air pressure regulator maintains the proper pressure within the seal by combining the functions of a pressure regulator, relief valve, and shutoff valve. A spring-loaded check valve is installed in the line between the high-pressure duct and the pressure regulator. This valve prevents pressure from backing into the engine bleed-air system duct when testing the canopy seal system and also traps pressure in the canopy seal in case of engine failure.

Ground pressurizing facilities are provided for testing during maintenance and pressurizing the canopy seal when the aircraft is stored on the carrier deck. These facilities are usually mounted on the cabin air pressure test panel as shown in figure 6-5. One connection is used for ground test; the other, which is normally the seal vent, is used for ground pressurization of the canopy seal. Ground pressurization is accomplished without the use of electric power on the aircraft. An air bottle with a regulator is connected to the seal vent and ground pressurization connection, and 15 psi air pressure is applied to the canopy seal. The external air pressure must remain attached to the connection to maintain pressure in the seal. When the air bottle is disconnected, the pressure in the seal is dumped.

NOTE: The seal vent and ground pressurization port has a small screen over the outlet which must be kept clean and free from obstructions.

Components

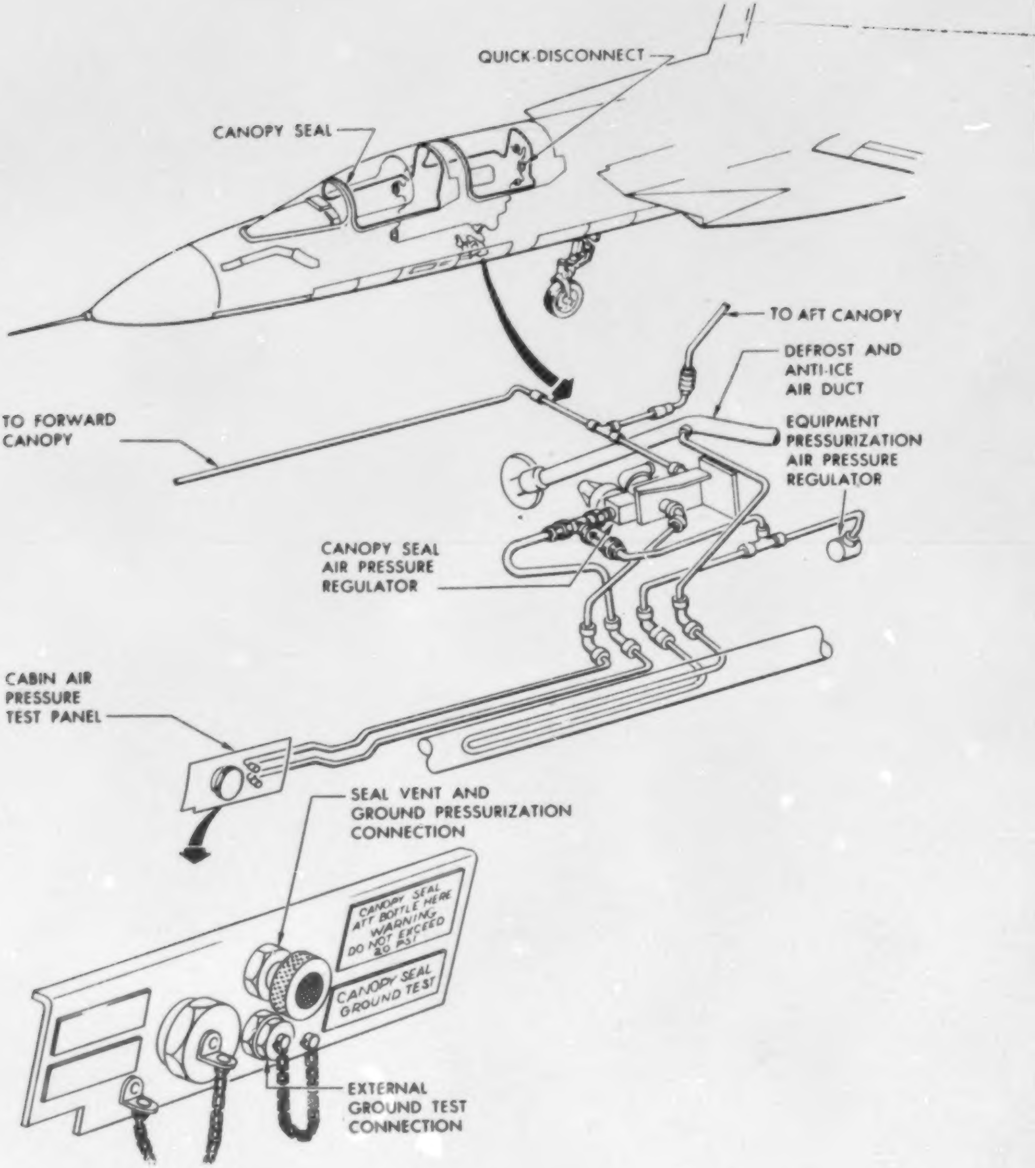
The components which make up the canopy seal system are shown schematically in figure 6-6. Of the components shown, only the pressure regulator and the canopy seal are discussed in detail.

PRESSURE REGULATOR.—The canopy seal regulator consists of three main sections: an air inlet and pressure regulator section; an air outlet, dump, and shutoff section; and a pressure relief section.

The air inlet and pressure regulator section incorporates a spring-loaded diaphragm that controls a poppet valve to regulate the pressure of outlet air. An adjustment screw at the top of the housing can adjust the regulating mechanism to maintain any desired pressure between 10 and 30 psi.

The air outlet, dump, and shutoff section incorporates a solenoid-operated poppet valve that is spring loaded to a normally closed position. When 28 volts d. c. is applied to the solenoid (canopy closed and locked), the poppet valve will close a dump port in the housing and open a shutoff passage. Regulated air from the inlet and pressure regulator section can then flow through the valve to inflate the canopy seal. When the solenoid is deenergized (canopy open), the poppet valve closes the shutoff passage and opens the dump port. This shuts off the flow of supply air, and the seal pressure is allowed to dump through the valve (vent port) to the overboard vent line.

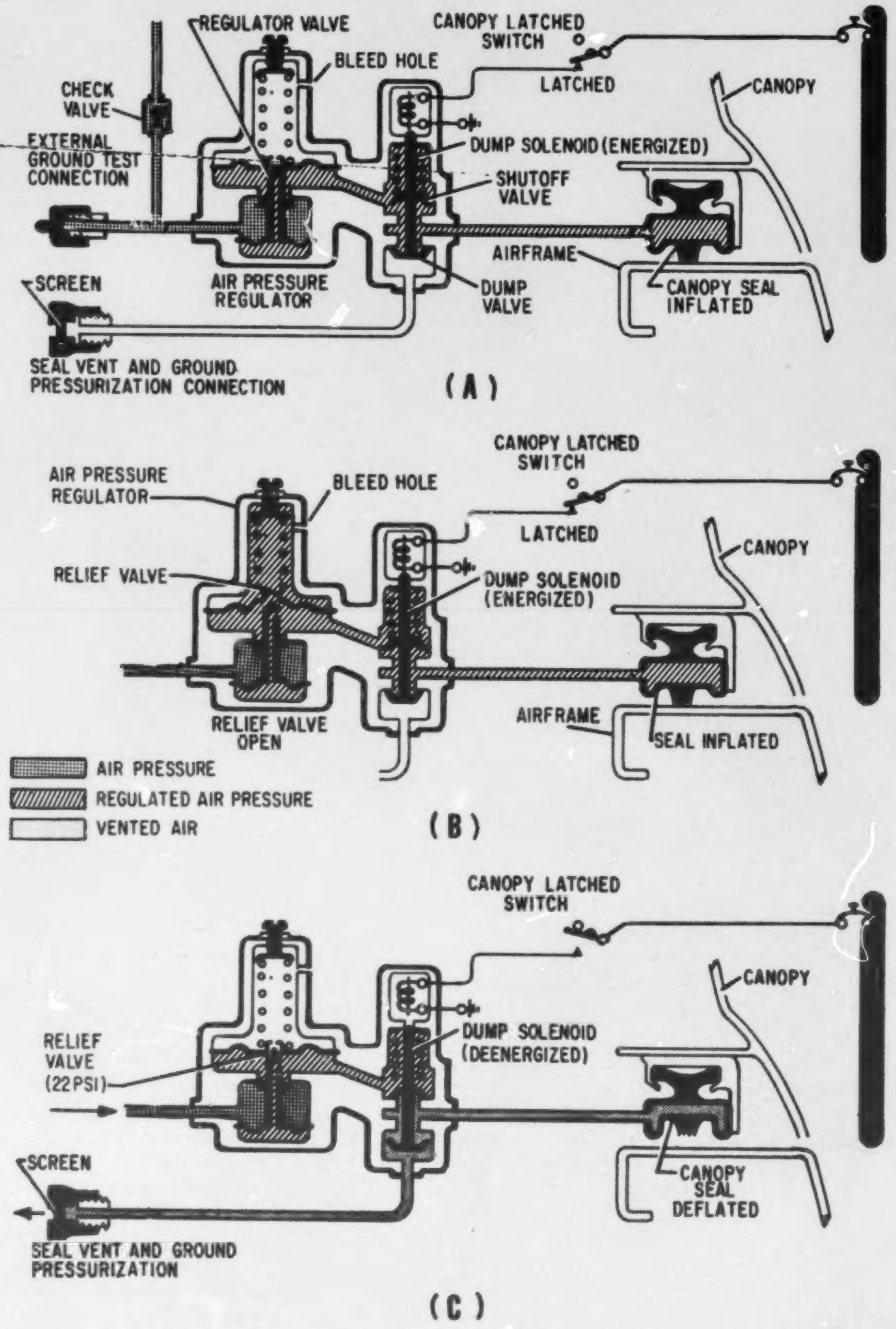
The pressure relief section incorporates a spring-loaded diaphragm that responds to seal pressure to open or close an escape vent. If seal pressure reaches a maximum of 22 psi, the


QUICK-DISCONNECT
CANOPY SEAL
TO AFT CANOPY
DEFROST AND ANTI-ICE AIR DUCT
TO FORWARD CANOPY
EQUIPMENT PRESSURIZATION AIR PRESSURE REGULATOR
CANOPY SEAL AIR PRESSURE REGULATOR
CABIN AIR PRESSURE TEST PANEL
SEAL VENT AND GROUND PRESSURIZATION CONNECTION
CANOPY SEAL ATT BOTTLE HERE WARNING DO NOT EXCEED 20 PSI
CANOPY SEAL GROUND TEST
EXTERNAL GROUND TEST CONNECTION

AM.104

Figure 6-5.—Canopy seal system installation.

escape vent opens and allows excessive pressure to drain to the atmosphere through a bleed hole. The relief section also prevents excessive pressure from building up within the regulator when the shutoff passage to the seal is closed.


REGULATOR VALVE
CANOPY LATCHED SWITCH
BLEED HOLE
CHECK VALVE
LATCHED
CANOPY
EXTERNAL GROUND TEST CONNECTION
DUMP SOLENOID (ENERGIZED)
SHUTOFF VALVE
AIRFRAME
SCREEN
AIR PRESSURE REGULATOR
DUMP VALVE
CANOPY SEAL INFLATED
SEAL VENT AND GROUND PRESSURIZATION CONNECTION
(A)
CANOPY LATCHED SWITCH
AIR PRESSURE REGULATOR
BLEED HOLE
LATCHED
CANOPY
RELIEF VALVE
DUMP SOLENOID (ENERGIZED)
RELIEF VALVE OPEN
AIRFRAME
SEAL INFLATED
AIR PRESSURE
REGULATED AIR PRESSURE
VENTED AIR
(B)
CANOPY LATCHED SWITCH
CANOPY
RELIEF VALVE (22 PSI)
DUMP SOLENOID (DEENERGIZED)
SCREEN
CANOPY SEAL DEFLATED
SEAL VENT AND GROUND PRESSURIZATION
(C)

AM.105

Figure 6-6.—Canopy seal system operation.

In the event of an electrical failure, the regulator automatically dumps as the solenoid is deenergized.

The canopy seal pressure regulator ports are marked IN, CANOPY, and VENT to insure proper installation.

CANOPY SEAL.—The canopy seal is an inflatable tube which is designed to fit in the crevice between the canopy frame and the fuselage frame. The seal is made of rubber and is designed for installation on the canopy without the use of adhesives. The seal is attached by inserting a molded flange into a U-shaped groove which is installed on the canopy. Figure 6-6 provides a cross-sectional view of the seal. The flange-to-channel installation facilitates easy removal and installation of the canopy seal.

The canopy seal is attached to the system by means of a short piece of tubing which extends from the interior of the seal through the bead. Treads on the seal contacting surface (fig. 6-6) mate with the surface of the cockpit frame to provide increased sealing qualities when the canopy is closed and the cockpit is pressurized.

Operation

Power for the operation of the pressure regulator is routed from the aircraft's 28-volt d-c electrical power system through the canopy latched switches to the solenoid-operated combination dump and shutoff valve. When the canopies are closed and locked (with the engines running), the solenoid is energized, thus causing the shutoff valve to open and the dump valve to close. (See A, fig. 6-6.) This allows regulated air to pressurize the canopy seal.

Should the canopy seal pressure reach a maximum of 22 psi (due to rapid altitude changes), the relief valve in the regulator will open (B, fig. 6-6) and vent the excess pressure overboard through the bleed hole in the regulator.

When either canopy is opened, the electrical circuit is broken, removing power from the solenoid. The dump valve then moves (spring loaded) to open the vent port and shut off the flow of air to the seals (C, fig. 6-6). With the VENT port open, canopy seal pressure flows back through the dump valve and vents overboard, thus deflating the seals. Seal pressure, in this instance, flows through the VENT port of the valve to the canopy seal vent fitting on the cabin air pressure test panel where it is vented overboard.

Mechanical/Hydraulic Controlled Canopy Seal System

The canopy seal control valve illustrated in figure 6-7 performs basically the same function as the electrically controlled valve covered previously and illustrated in figure 6-6. The primary difference in the two valves is the means of controlling them. This valve is mechanically actuated to initiate inflation of the canopy seal and is hydraulically tripped to shut off and dump seal pressure.

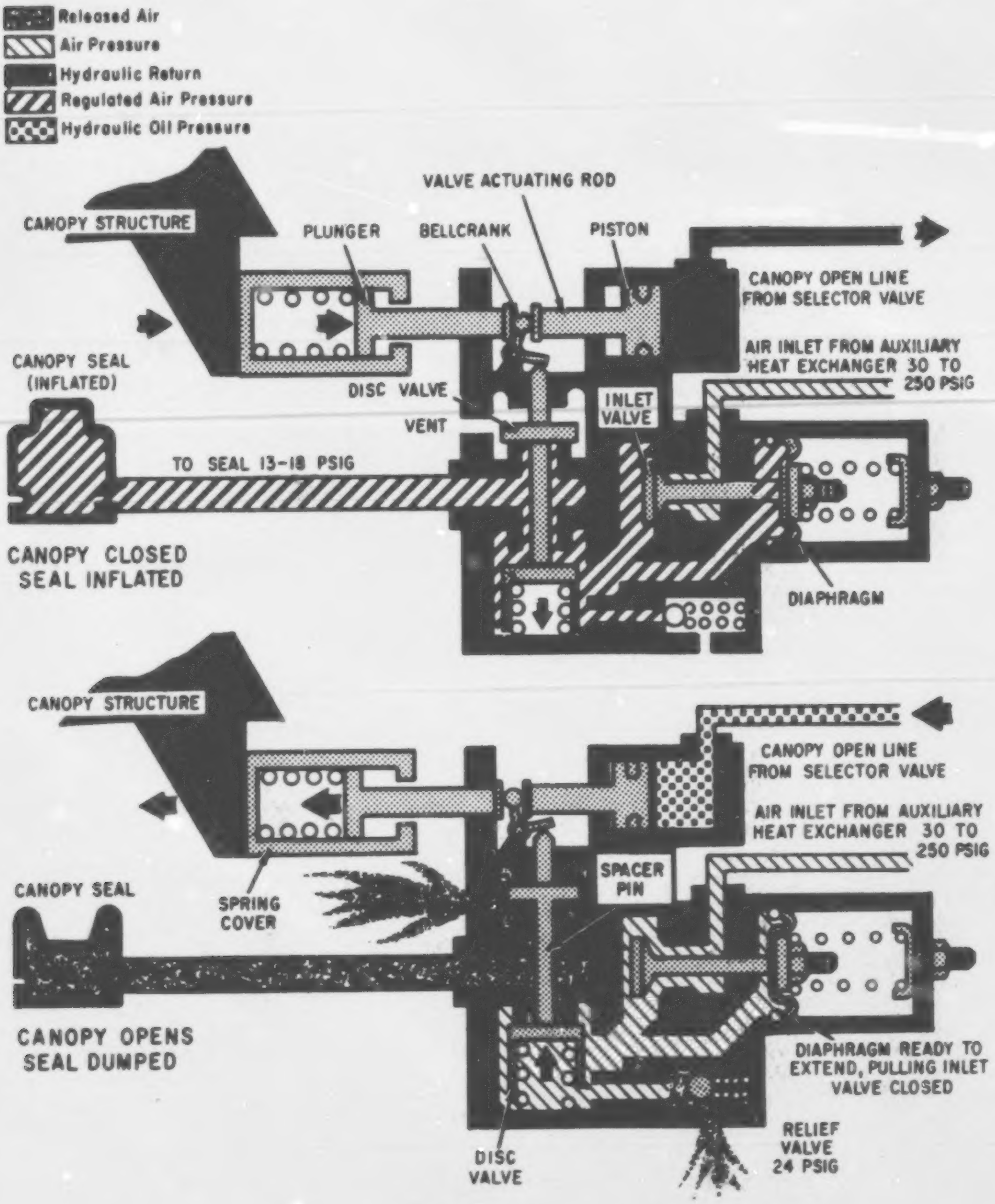
As the canopy approaches the fully closed position, the canopy structure contacts the valve spring cover, slightly compressing the spring inside. The compressed spring causes the valve plunger to move against the bellcrank. The bellcrank, in turn, forces the disc valve assembly to move downward against spring pressure, closing the bleed-air dump vent and opening the lower disc valve to port regulated bleed-air pressure to the canopy seal.

The bleed air utilized to inflate the seal has been cooled by passing it through the auxiliary heat exchanger of the aircraft's environmental control systems. The pressure of the bleed air, as it enters the canopy seal valve and flows into the regulating chamber, will be in a range of 30 to 250 psi.

As bleed-air pressure in the regulating chamber builds up, the diaphragm of the adjustable pressure regulator section of the canopy seal valve will maintain a regulated air pressure to the seal in a range from 13 to 18 psi. The relief valve in the regulating chamber is set to open at 24 psi as a safety backup in the event of regulator failure.

When the canopy switch is positioned to OPEN, hydraulic pressure from the canopy open line first flows to the canopy seal control valve. The hydraulic pressure acting on the piston causes the piston, the bellcrank, and the plunger to move against spring tension. Tripping of the bellcrank allows the disc valve assembly to move upwards, shutting off bleed-air pressure and dumping canopy-seal pressure. The seal deflates and then the canopy proceeds to open. As the canopy structure moves away from the plunger, spring tension is relieved and the bellcrank stays in the dump position.

Notice in the seal dumped and canopy opening view (fig. 6-7) that the relief valve is open. The closing of the lower disc valve, which stops incoming bleed air, causes a momentary overpressurization within the pressure regulating


Released Air
Air Pressure
Hydraulic Return
Regulated Air Pressure
Hydraulic Oil Pressure
VALVE ACTUATING ROD
CANOPY STRUCTURE
PLUNGER
BELLCRANK
PISTON
CANOPY OPEN LINE FROM SELECTOR VALVE
AIR INLET FROM AUXILIARY HEAT EXCHANGER 30 TO 250 PSIG
CANOPY SEAL (INFLATED)
DISC VALVE
VENT
INLET VALVE
TO SEAL 13-18 PSIG
CANOPY CLOSED SEAL INFLATED
DIAPHRAGM
CANOPY STRUCTURE
CANOPY OPEN LINE FROM SELECTOR VALVE
AIR INLET FROM AUXILIARY HEAT EXCHANGER 30 TO 250 PSIG
SPACER PIN
CANOPY SEAL
SPRING COVER
CANOPY OPENS SEAL DUMPED
DIAPHRAGM READY TO EXTEND, PULLING INLET VALVE CLOSED
RELIEF VALVE 24 PSIG
DISC VALVE

AM.1147

Figure 6-7.—Canopy seal control valve operation.

chamber. The relief valve will open until the pressure within the chamber has had time to act on the regulating diaphragm and close the bleed-air inlet valve and pressure drops below 24 psi.

ANTI-G SYSTEMS

The purpose of an anti-g system is to supply air pressure for inflating the pilot's anti-g suit. The anti-g suit is worn to counteract the effects of prolonged acceleration on the pilot. The ill effects of such acceleration may range from excessive fatigue and decreased alertness to blackout and unconsciousness.

Though there is no limit to the speed a human being can endure in straight and level flight in an aircraft, changing speed or direction can lead to reactive forces of inertia to which the body has a sharply limited tolerance. In the case of extreme stresses exerted by acceleration of the type met in seat ejection, the short duration of the acceleration restricts its effects. However, changing the direction of flight often produces prolonged radial acceleration (longer than a second) which can have dangerous effects.

At 5 g's the pilot's body is exposed to a force of inertia which increases its "weight" and that of its components five times. This increased "weight" has many effects. The pilot is pushed down into his seat. His arms and legs feel like lead, and manipulation of the controls becomes more difficult. In addition, the extra weight of the viscera (internal organs) causes abdominal and chest discomfort. Most important, however, is the effect on the circulatory system.

At 5 g's the pressure exerted by the column of blood between the head and the heart becomes just about equal to the blood pressure in the arteries. As a result, the pressure supplied by the heart is not great enough to pump an adequate supply of blood to the head.

To counteract these effects, the arterial pressure must be increased above the heart level. At the same time, distended vessels and tissue and fluid spaces in the regions below the heart must be restored to normal. This is accomplished by the anti-g suit. With the anti-g system, compressed air is metered to the suit in proportion to the acceleration, and the suit compresses the legs and abdomen of the wearer by an amount proportional to the acceleration. Thus, the suit prevents venous pooling in the abdomen and lower extremities and forces blood from the lower to the upper part of the body. This effect increases venous return to the heart and increases resistance to the shifting of blood to the lower limbs. In addition, it causes the diaphragm to be raised and thus decreases the distance between the heart and the eyes and/or the brain. Altogether, it increases the tolerance of the pilot an average of about 2 g's.

Without an anti-g suit, the average pilot can withstand 4.5 to 5.5 g's without losing vision or blacking out. With a suit, he is capable of withstanding 6.0 to 7.0 g's. However, this protection is available only for sustained accelerations of 4 to 5 seconds or longer in maneuvers other than snap maneuvers. Anti-g equipment does not offer protection in snap maneuvers where 10 to 12 g's can be applied in approximately 1 second. Such brief forces are not as harmful to the body as lesser forces which are sustained for a number of seconds.

Typical Anti-G System

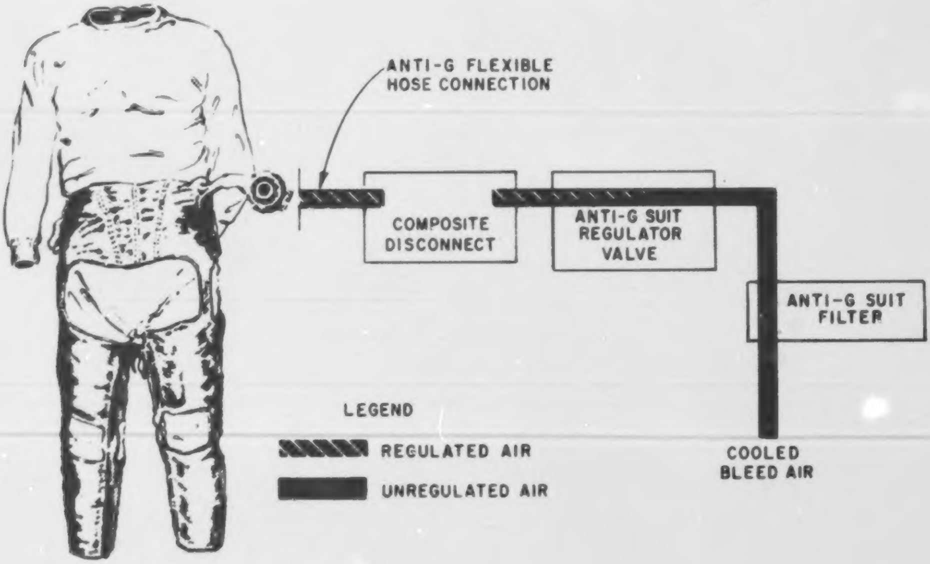
Most anti-g systems are similar to the one illustrated in figure 6-8. The anti-g system usually consists of a supply line, an air filter, a pressure regulating valve, a connecting hose, and a suit attachment fitting (quick disconnect). The air pressure supply line is connected into the aircraft's bleed-air system downstream of the heat exchanger.

The air pressure for inflating the anti-g suit is regulated by the pressure regulating (anti-g) valve. The pressure regulating valve begins to function at a predetermined number of g's. The amount of pressure delivered depends on the type of regulator installed in the aircraft. NOTE: There are two types of anti-g valves in current use—a two-stage valve and a single-stage valve.

The operation of the anti-g system is automatic except for systems which utilize the two-stage valve. The pilot plugs his anti-g suit into the quick disconnect; and when the aircraft is in flight, air pressure is supplied to the suit in proportion to the g load imposed on the aircraft. Operation of the pressure regulator and various other components is discussed in the following paragraphs.

Pressure Regulating (Anti-G) Valves

PRESSURE REGULATING VALVE (TWO-STAGE).—This regulating valve is a standard unit which is used on several naval aircraft models. The regulating valve is mounted on the console near the pilot's seat.



AM.1148

Figure 6-8.—Anti-g system schematic.

The pressure regulating valve regulates the pressurized air received from the aircraft's bleed-air system to provide the proper pressure for the operation of the pilot's anti-g suit. The valve begins to function at a predetermined number of g's. Pressure delivered depends upon the setting of the control knob (fig. 6-9) which is marked HI and LO.

When the control knob is set at LO, the valve opens at approximately 1.75 g's and then subsequently, allows 1 psi air pressure to pass to the suit for each additional increment of 1 g. For example, at 3 g's the valve delivers 1.25 psi air pressure to the suit.

When the control knob is set at HI, the valve opens at approximately 1.75 g's and then delivers 1.5 psi air pressure for each increment of 1 g above 1.75 g's. For example, at 3 g's the valve allows 1.87 psi air pressure to pass to the suit.

When accelerations decrease below 1.75 g's, the valve closes and exhausts the suit pressure into the cabin atmosphere, thus allowing the suit to deflate.

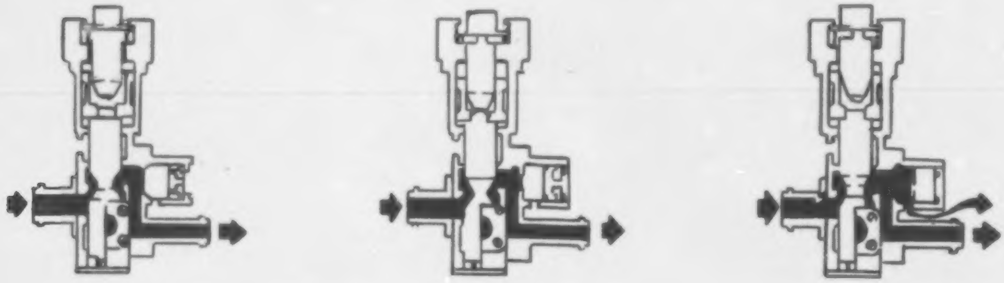
The valve assembly contains a relief valve that acts as a safety device by limiting air pressure to the suit in case of a valve failure, a test button to facilitate inspection of valve operation, and two connection fittings.

One of the connection fittings, marked IN, receives the inlet air pressure from the engine compressor section; the other fitting, marked OUT, on the relief valve side, delivers outlet pressure to the anti-g suit. There are three additional screened openings on the valve, but they do not serve as connection points. They are the discharge outlet, the suit vent, and the relief valve opening. It is necessary that the air from these openings be discharged into the cockpit atmosphere in order to maintain proper differential pressures in the suit.

A manual test button is located in the control knob recess for testing the valve for operation. The pressure regulating valve requires no maintenance and no repairs can be made. A defective valve assembly should be replaced with a new unit.

PRESSURE REGULATING VALVE (SINGLE-STAGE).—The newer aircraft are designed with an anti-g system which has a single-stage type pressure regulating valve. This valve (fig. 6-10) utilizes the high-pressure features of the two-stage valve.

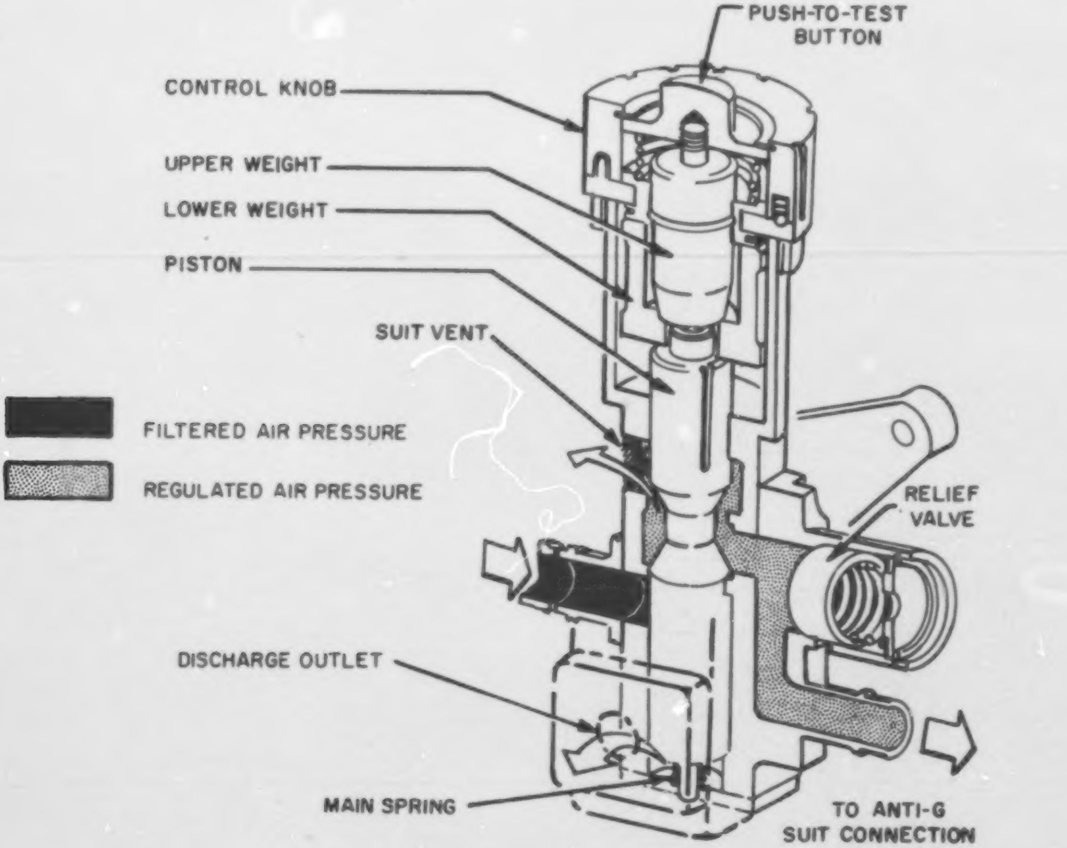
The valve begins to open at approximately 1.5 g's, and pressure is supplied to the suit at the rate of 1.5 psi for each additional g.



VALVE OPEN AND SUIT BEING INFLATED ("LO" RANGE)

VALVE OPEN AND SUIT BEING INFLATED ("HI" RANGE)

RELIEF VALVE RELIEVING EXCESS PRESSURE


PUSH-TO-TEST BUTTON
CONTROL KNOB
UPPER WEIGHT
LOWER WEIGHT
PISTON
SUIT VENT
FILTERED AIR PRESSURE
REGULATED AIR PRESSURE
RELIEF VALVE
DISCHARGE OUTLET
MAIN SPRING
TO ANTI-G SUIT CONNECTION

AM.108

Figure 6-9.—Anti-g valve (two stage).

This valve is designed to receive air pressure from the bleed-air system at varying pressures and to meter a maximum of 10 psi to the anti-g suit. A relief valve bleeds off the excess air pressure and maintains a maximum of 9 to 11 psi in the valve outlet chamber. Figure 6-11 illustrates the operation of the single-stage anti-g valve.

When a force of approximately 1.5 g's is exerted on the aircraft, the activating weight overcomes the upper spring tension and closes the exhaust valve (A, fig. 6-11). As the weight travels downward, it further depresses the valve assembly, forcing the demand valve from its seat, thus overriding the pressure of the lower spring and opening the demand valve. Air pressure then flows past the open demand valve, through the valve outlet into the valve outlet line, through the suit quick disconnect, and into the anti-g suit.

As the g forces being applied to the aircraft are stabilized and becomes constant, the pressure under the activating weight diaphragm builds up sufficiently to lift the weight and to reduce the pressure on the valve assembly enough to close the demand valve (B, fig. 6-11). The demand valve closes under pressure of the heavier lower spring, while the exhaust valve remains closed by the activating weight. The suit pressure is then trapped in the outlet chamber of the anti-g valve and remains constant until the g forces change.

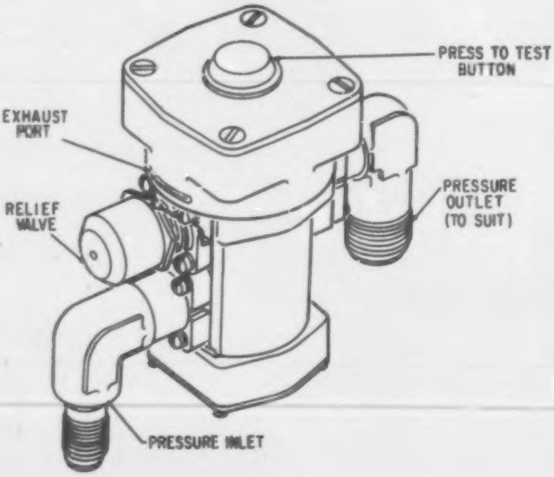
As the g forces decrease, the downward force on the activating weight diminishes to a point at which the upper spring lifts the weight off the exhaust valve. The pressure in the suit is then vented through the exhaust port (C, fig. 6-11) into the cockpit.

Anti-G System Filter

Figure 6-12 illustrates an anti-g system filter. It is installed in the air pressure supply line before the anti-g system pressure regulating valve as shown in figure 6-8. The filter prevents foreign matter, dust, and abrasives from being blown through the lines into the regulator. The filter element is removable and should be replaced at the interval prescribed in applicable maintenance requirements card deck or as specified in the Maintenance Instructions Manual.

Quick Disconnects

The anti-g suit is connected to the anti-g system by means of a quick-disconnect coupling. This quick disconnect may be either a single unit which connects the anti-g suit only, or it may be a composite quick disconnect which connects the pilot to the various personal service lines (oxygen, ventilating air, anti-g system, and communications).



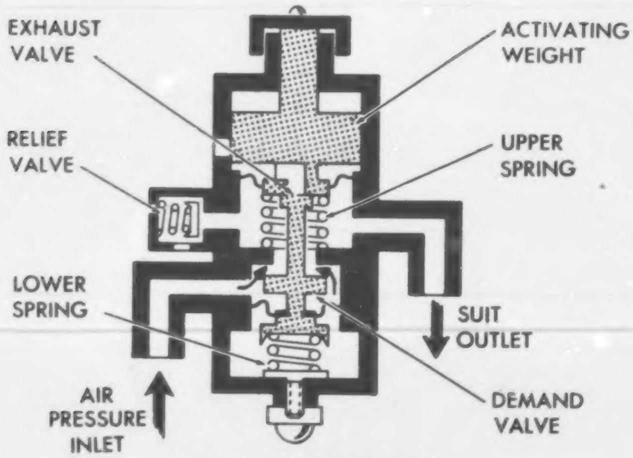
AM.109

Figure 6-10.—Anti-g pressure regulating valve (single stage).

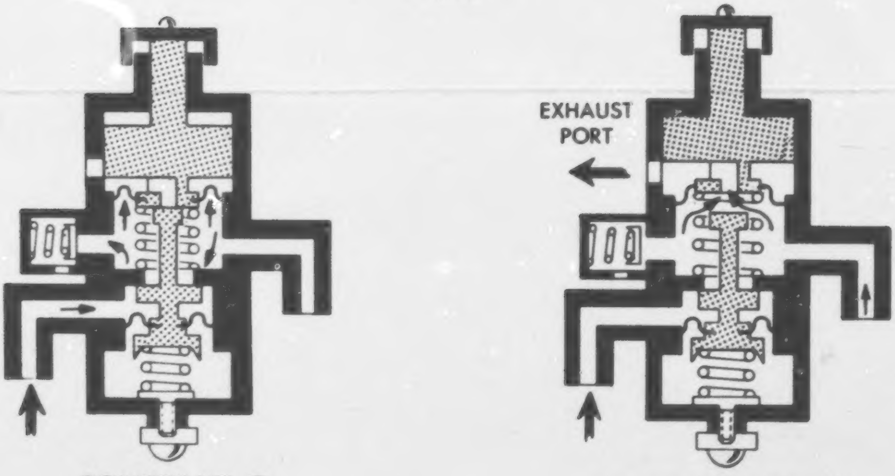
ANTI-G QUICK DISCONNECT.—The anti-g system quick disconnect is used on aircraft which are not equipped with a composite quick disconnect attached to the ejection seat. This disconnect is on a hose which protrudes through the pilot's console. It is attached by a flexible hose to the outlet port of the anti-g pressure regulating valve. This disconnect may be pulled up to a bumper stop to facilitate connecting the anti-g suit hose. A spring-loaded cover on the disconnect prevents the entry of foreign material when the system is not in use.

COMPOSITE QUICK DISCONNECT.—The new high-performance aircraft utilize a composite quick disconnect to provide a single point connection for quick connecting and disconnecting the anti-g, oxygen, ventilation air, and communications systems to the pilot's equipment.

The composite quick disconnect illustrated in figure 6-13 provides a connection for all of the previously mentioned systems. Some disconnects provide a connection point for only one or more of these systems with any remaining


EXHAUST VALVE
ACTIVATING WEIGHT
RELIEF VALVE
UPPER SPRING
LOWER SPRING
SUIT OUTLET
AIR PRESSURE INLET
DEMAND VALVE

SUIT INFLATION
(A)


EXHAUST PORT

CONSTANT G CONDITION
(B)

STATIC POSITION SUIT EXHAUST
(C)

AM.110

Figure 6-11.—Anti-g valve operation (single stage).

system connections located on the left or right cockpit consoles as necessary to provide easy connecting and disconnecting.

This disconnect consists of three separate blocks. The lower block is attached to the aircraft, the intermediate block is attached to the

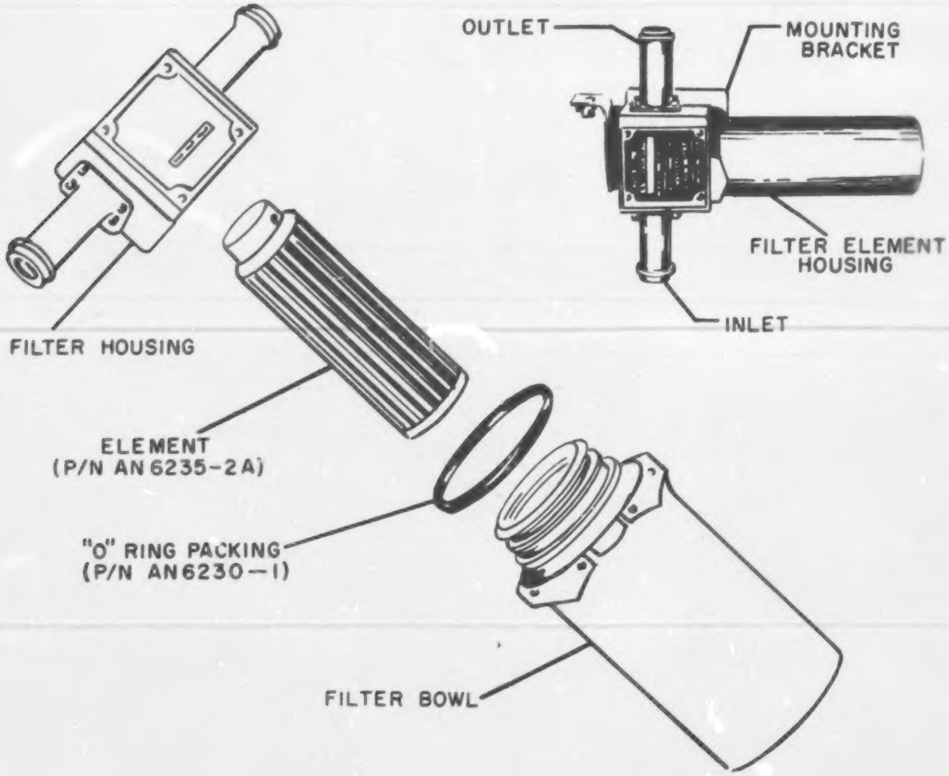


Figure 6-12.—Anti-g system filter.

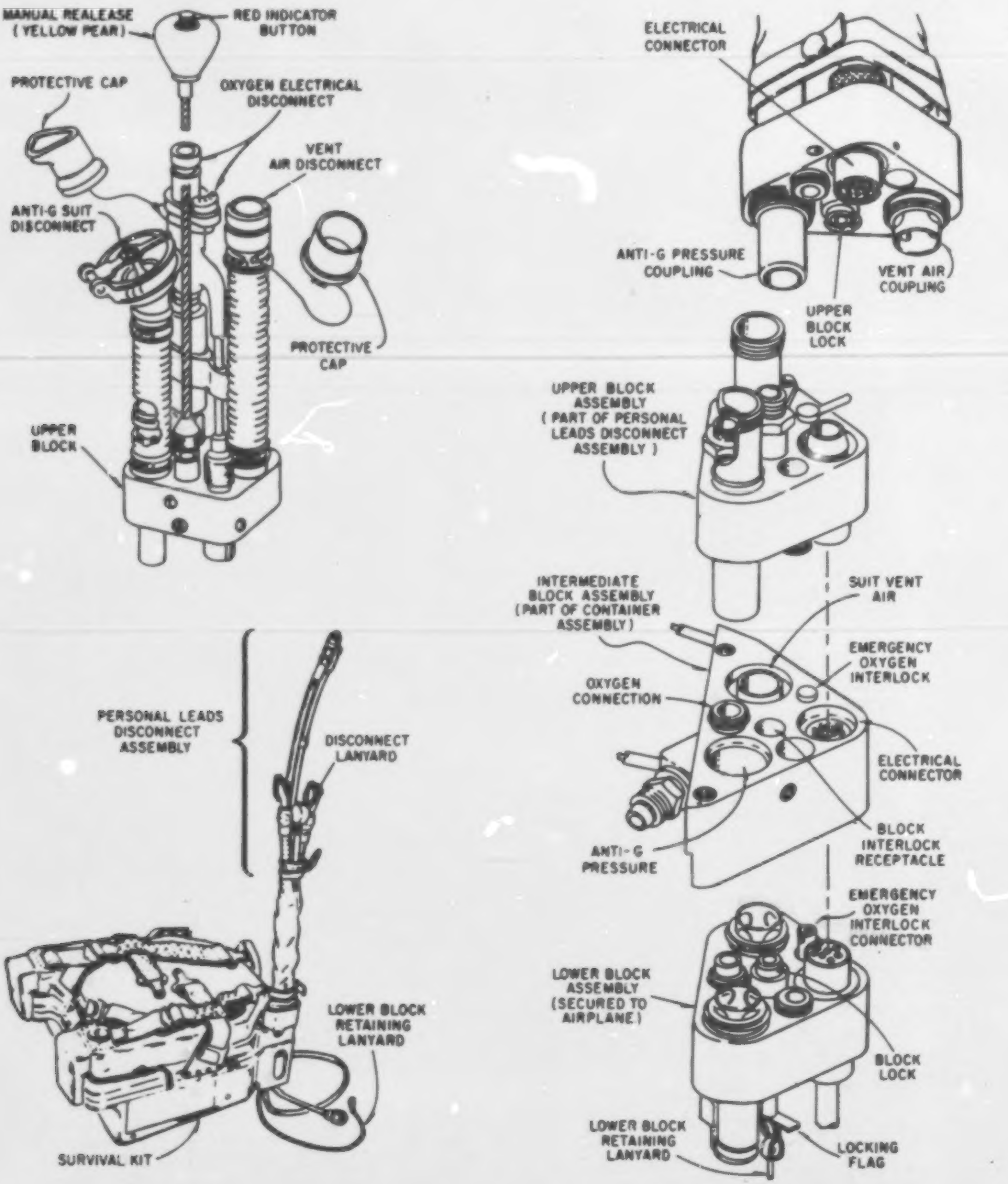
survival kit, and the upper block is part of the pilot's personal leads disconnect assembly.

NOTE: The survival kit mentioned above is used to house the pilot's life raft, first aid kit, and the emergency supply of oxygen. It forms the pilot's seat in the ejection unit and is detached from the unit when the pilot leaves the seat after ejection.

The lower block of the composite quick disconnect is connected to the cockpit deck under the seat by a lanyard. It provides a means of separating the aircraft's personal services from the seat in the event of ejection. A ball locking mechanism is incorporated to lock the lower block to the intermediate block. An emergency oxygen system interlock mechanism is used to actuate the emergency oxygen system when the ejection seat is fired.

The lower block is pulled from the survival kit during the ejection sequence by the release lanyard, which is attached to the cockpit deck. A ditching ring attached to the release lanyard releases the lower block when the pilot leaves the aircraft after ditching (a crash landing at sea).

The intermediate block is secured to the survival kit container and provides a mounting receptacle for the upper and the lower blocks. The intermediate block contains an emergency oxygen feature which automatically provides the pilot with oxygen when the seat is ejected from the aircraft.


MANUAL REALEASE (YELLOW PEAR)
RED INDICATOR BUTTON
PROTECTIVE CAP
OXYGEN ELECTRICAL DISCONNECT
VENT AIR DISCONNECT
ANTI-G SUIT DISCONNECT
PROTECTIVE CAP
UPPER BLOCK
ELECTRICAL CONNECTOR
ANTI-G PRESSURE COUPLING
VENT AIR COUPLING
UPPER BLOCK LOCK
UPPER BLOCK ASSEMBLY (PART OF PERSONAL LEADS DISCONNECT ASSEMBLY)
INTERMEDIATE BLOCK ASSEMBLY (PART OF CONTAINER ASSEMBLY)
SUIT VENT AIR
EMERGENCY OXYGEN INTERLOCK
OXYGEN CONNECTION
ELECTRICAL CONNECTOR
ANTI-G PRESSURE
BLOCK INTERLOCK RECEPTACLE
EMERGENCY OXYGEN INTERLOCK CONNECTOR
PERSONAL LEADS DISCONNECT ASSEMBLY
DISCONNECT LANYARD
LOWER BLOCK ASSEMBLY (SECURED TO AIRPLANE)
BLOCK LOCK
LOWER BLOCK RETAINING LANYARD
SURVIVAL KIT
LOWER BLOCK RETAINING LANYARD
LOCKING FLAG

AM.1149

Figure 6-13.—Composite quick disconnect.

The upper block is connected to the upper surface of the intermediate block. The connection between the upper and intermediate block is sealed with O-rings, located in the upper block.

The upper block release knob is used to disengage the upper block from the intermediate block. The upper block locking indicator (red button on the manual release) should be flush with the release knob when the blocks are properly locked together. The proper locking of the lower block to the intermediate block is indicated by the lower block locking indicator flag. If the lower and intermediate blocks are properly locked together, the flag will be held firmly in position as indicated in figure 6-13. If the flag is free to move up and down, the blocks are not properly locked.

VENT-AIR SYSTEMS

Vent-air systems provide a flow of air to the aircraft's seat or back cushions or to the ventilating air connection of the antiexposure suit when worn by the pilot and/or crewmembers. The system provides a definite measure of personal comfort, offsetting the discomfort caused by the wearing of the antiexposure suit or heat created by cockpit equipment and high temperature ambient air.

Some vent-air systems, such as the one installed in the A-4 model aircraft, supply air to only one individual and operate on a small independent motor-driven air blower. Most newer aircraft utilize engine bleed air that has been cooled in the aircraft air-conditioning system auxiliary heat exchanger as a primary source of ventilation air. A schematic of a typical vent-air system that operates off engine bleed air is illustrated in figure 6-14.

This system is supplied cooled bleed air from the refrigeration unit of the aircraft's cabin air-conditioning and pressurization system and hot bleed air from the hot bleed-air ducting just downstream of the engine bleed-air shutoff valve as illustrated in figure 5-1. The hot and cold bleed-air lines converge into one conditioned air duct that is connected directly to the pilot's and bombardier/navigator's flow controllers and the personnel services disconnect.

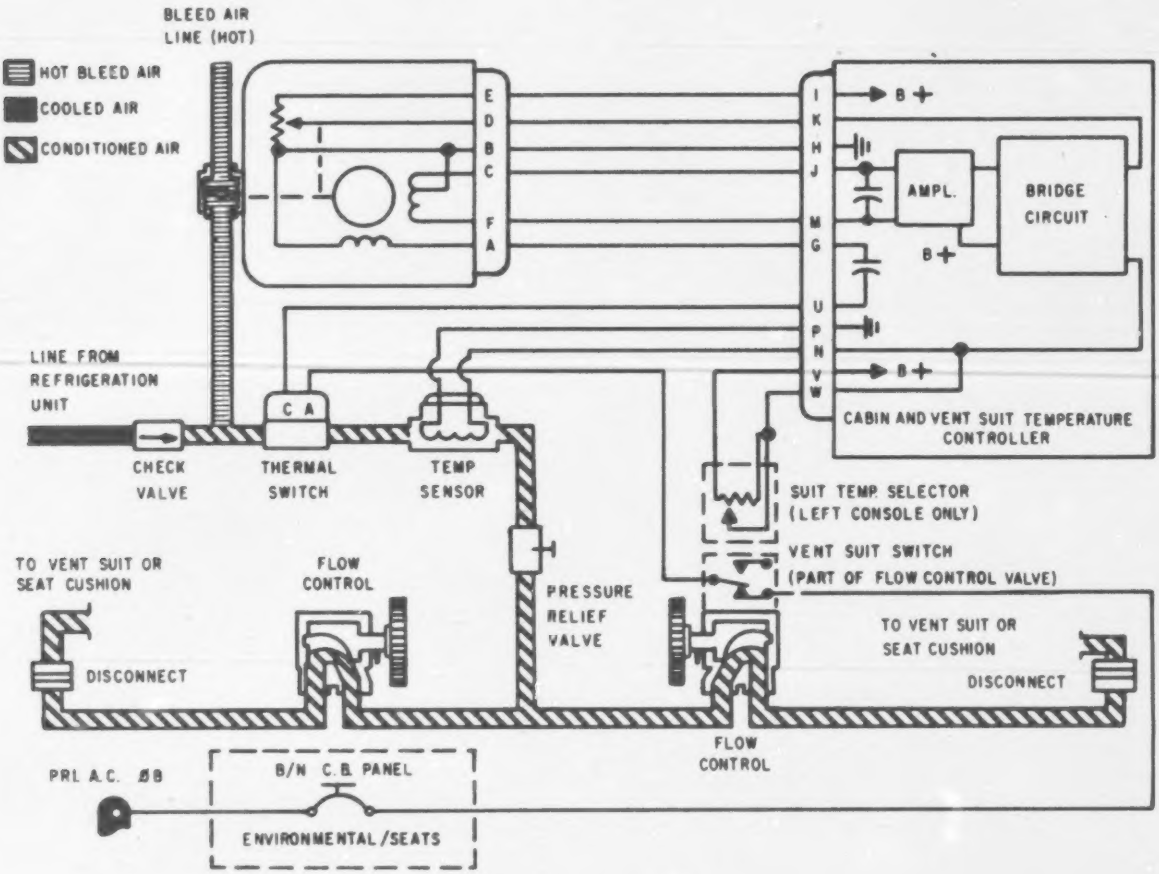
Temperature control of the vent-system air is regulated between 50° F and 100° F by the vent suit temperature selector, the temperature control valve, a temperature sensor, and the cabin and vent suit temperature controller. The components of the temperature control system cause the temperature control valve to cycle between open and close. Thus, temperature control is maintained by governing the flow of hot engine bleed air that is being mixed with cool air from the refrigeration unit.

The vent-air system is turned on by the vent suit switch. This switch is an integral part of the pilot's flow controller. When the flow control valve thumbwheel is rotated slightly from the OFF position, the circuit between the temperature sensor and the cabin and vent suit controller is completed. The controller responds to signals from the temperature sensor and the temperature selector and supplies open and close signals, as appropriate, to the vent suit temperature control valve.

The vent-air flow controllers, as the name implies, control the flow of air from the vent-system ducting to the personnel services disconnects and the seat cushion or the vent connection of the antiexposure suit. One controller is provided for each crewmember. The controller has an inlet connector, an outlet connector, and a thumbwheel-operated flow controller. The thumbwheel shaft connects to a rotating plug which gradually opens or closes off the outlet port as it rotates up to a maximum of 180 degrees. The flow controller will be fully open when turned to the full counterclockwise position.

The temperature selector is a thumbwheel-operated potentiometer, located on the pilot's console, aft of the flow controller thumbwheel. Only one temperature selector serves both vent suit outlets. The thumbwheel is numbered 1 through 14, and the console is labeled HOT and COLD. Turning the thumbwheel clockwise to the lower numbered settings lowers the temperature of vent system air. Counterclockwise movement towards the hot position and the higher numbered settings increases the temperature.

Response to temperature changes initiated by repositioning the temperature selector thumbwheel will be noticeable at the disconnect outlet within a few seconds after making a selection change. When the aircraft is in a stabilized flight condition (maintaining a steady altitude), the temperature of vent air will be monitored and controlled within a ±2 °F tolerance of the temperature selected by the temperature selector thumbwheel. When the aircraft is transisting (changing altitude), the temperature is maintained within a ±10° F tolerance.


BLEED AIR
LINE (HOT)
HOT BLEED AIR
COOLED AIR
CONDITIONED AIR
E
D
B
C
F
A
I
K
H
J
M
G
U
P
N
V
W
B+
AMPL.
BRIDGE CIRCUIT
B+
B+
CABIN AND VENT SUIT TEMPERATURE CONTROLLER
LINE FROM REFRIGERATION UNIT
C A
CHECK VALVE
THERMAL SWITCH
TEMP SENSOR
SUIT TEMP. SELECTOR (LEFT CONSOLE ONLY)
VENT SUIT SWITCH (PART OF FLOW CONTROL VALVE)
TO VENT SUIT OR SEAT CUSHION
FLOW CONTROL
PRESSURE RELIEF VALVE
TO VENT SUIT OR SEAT CUSHION
DISCONNECT
DISCONNECT
FLOW CONTROL
PRI. A.C. ØB
B/N C.B. PANEL
ENVIRONMENTAL/SEATS

AM.1150

Figure 6-14.—Vent-air system.

The thermal switch senses any abnormally high temperatures not compensated for by the temperature sensor and will provide a signal, via the cabin and vent suit temperature controller, to the temperature control valve to drive it towards the closed position.

The system pressure relief valve protects the system from accidental overpressurization. The relief valve will open as necessary to prevent vent-system ducting pressure from exceeding 10 psi.

The check valve prevents conditioned air from backing up into the environmental control system ducting. Cooled air flows through the check valve, is mixed with the appropriate amount of hot bleed air, and is forced into the vent-air system ducting.

MAINTENANCE

Organizational level maintenance of the auxiliary bleed-air systems discussed in this chapter generally includes the removal and replacement of components and associated plumbing, periodic inspections, and performing of operational checkouts.

Some steps of the operational checkout will be performed by personnel of the AE rating utilizing an environmental control test set like the one mentioned in chapter 5. Most steps of the operational checkout will be accomplished by the joint effort of personnel from both the AME and AE ratings.

During periodic inspections, the auxiliary bleed-air system ducting is inspected for pressure tightness and general integrity. A leak in any high-pressure bleed-air line can result in a concentration of heat and subsequent damage to surrounding aircraft structure and components.

Suspected leaks should be checked and corrected prior to further flight. The periodic inspections should always be accomplished with strict conformance to the applicable Maintenance Requirements Cards (MRC's). Removal and installation of any components should be accomplished as outlined in the specific Maintenance Instructions Manual.

Insure that all tubing connectors (Marman clamps, V-band couplings, etc.) are installed, torqued, and safetied properly and that each maintenance action is verified by a quality assurance representative or a collateral duty inspector.

Windshield Anti-Icing and Rain Removal Operational Check

When performing an operational check of the windshield anti-icing and rain removal system, insure that the time limit for directing hot bleed air onto the windshield panel is not exceeded. The windshield panels are installed with space allotted for normal expansion, but excessive heating of the panel will cause abnormal expansion and the stress of the panel against the surrounding structure could cause the panel to crack.

On some aircraft, a windshield overheat warning light is provided on the instrument panel. The warning light will glow whenever the air temperature directed on the panel exceeds a predetermined value (usually about 300° F).

Canopy Seal System

A report of fluctuating cabin pressurization or a lack of pressurization could be caused by a leak in the canopy seal. Inspection of the canopy seal should be accomplished on every occasion of inspecting the aircraft's pressurization system. The seal must be inspected closely for cuts, tears, cracks, abrasion, deterioration, and any other damage that could result in leakage.

The procedure for performing a leakage test of the canopy seal illustrated in figures 6-5 and 6-6 is as follows:

1. Apply external electrical power to the aircraft.
2. Close and lock canopies.
3. Connect external air source and rate-of-flow meter to the canopy seal ground test fitting.
4. Pressurize the canopy seal to 20 psig.
5. Shut off air supply source for a period of 15 minutes.
6. Insure that leakage during the 15-minute period does NOT exceed 2.0 psig.
7. If leakage is excessive, check for leaks in system by using soap (MIL-S-4282A) and water solution on fittings and seal.
8. Disconnect external air source and rate-of-flow meter.
9. Disconnect external electrical power.

Damaged or leaking seals should be removed and repaired or replaced. Slight tears and abrasions confined to small areas can occasionally be repaired with sealant as specified in the applicable Maintenance Instructions Manual.

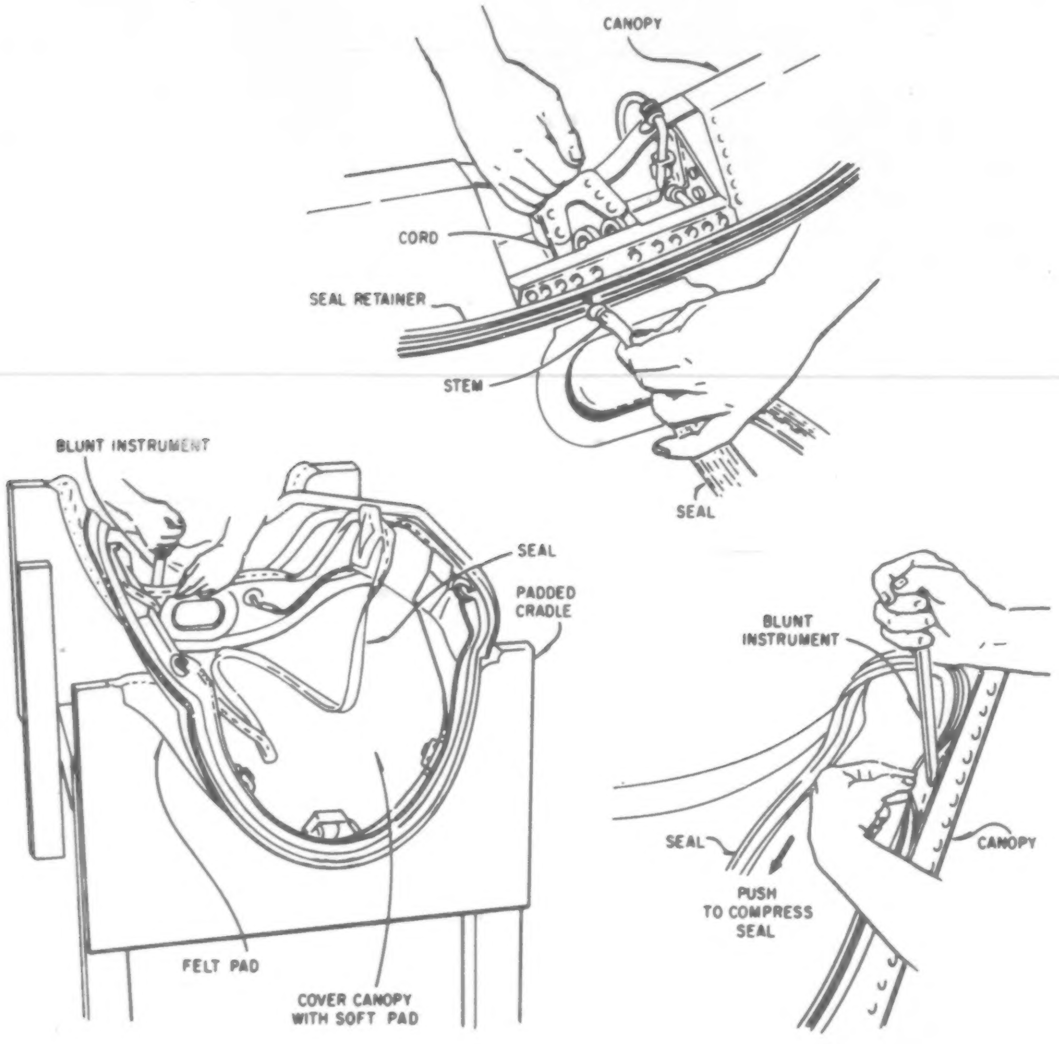
A typical removal and installation procedure is described in the following paragraphs.

REMOVAL PROCEDURE.—The canopy seal is removed as follows:

1. Remove the canopy in accordance with the instructions contained in the applicable Maintenance Instructions Manual. Place the canopy in a suitable cradle in order to gain access to the canopy seal.(See fig. 6-15.)
2. Start at the canopy seal connection at the aft end of the canopy and gently pull the seal from the canopy channel.
3. Continue pulling the seal from around the entire canopy.
4. With the seal removed from the canopy channel thoroughly clean the channel of dirt and other foreign material.
5. Disconnect the clamp which secures the canopy seal hose to the pressure line.
6. Inspect and test the seal. If the seal is found damaged, procure a new seal for installation.

INSTALLATION PROCEDURE.—The canopy seal is installed as follows:

1. Position the seal in the canopy with the seal hose at the aft end of the canopy and aligned with the tubing access notch in the canopy channel. Utilize a piece of cord to pull the seal stem through the opening in the seal retaining channel as shown in figure 6-15.


CANOPY
CORD
SEAL RETAINER
STEM
SEAL
BLUNT INSTRUMENT
SEAL
PADDED CRADLE
FELT PAD
COVER CANOPY WITH SOFT PAD
BLUNT INSTRUMENT
SEAL
CANOPY
PUSH TO COMPRESS SEAL

AM.1151

Figure 6-15.—Canopy seal installation.

2. Connect the seal hose to the system pressure line and tighten the retaining clamp.

3. Start at the seal hose and insert one edge of the canopy seal flange into the channel groove.

4. Force the opposite edge of the seal flange into the seal groove utilizing a blunt edged instrument as illustrated in figure 6-15. The tool may be fabricated from 1/8-inch thick aluminum with the end filed to form a smooth curve that will not damage the seal.

5. Work in both directions from the seal hose until the entire seal flange is installed in the channel.

6. If the seal is too short or too long at the completion of the installation, work the seal

around the entire channel, either stretching or compressing to gain or remove the slack.

7. Check to insure that the seal flange is deeply and smoothly installed in the channel and securely connected to the pressure line.

8. Install the canopy on the aircraft.

9. Perform an operational check on the canopy installation and the canopy seal system.

Many of the components of the auxiliary bleed-air systems can be partially disassembled and repaired at the Intermediate level maintenance activity. Section IV of the applicable Maintenance Instructions Manual provides a listing of parts available in kits or as individual items and replaceable at the AIMD level. Repair procedures in section IV include disassembly, cleaning, inspection, reassembly, and testing as necessary to return the part to a ready for issue (RFI) condition.

Parts that cannot be repaired utilizing the parts available to the AIMD are forwarded via the supply system to the designated Depot level maintenance activity for complete overhaul.

DEICER/ANTI-ICING SYSTEMS

On days when there is visible moisture in the air, ice can form on the aircraft leading edge surfaces at altitudes where the freezing temperature starts and above. Water droplets in the air can be supercooled to a below freezing temperature without actually turning into ice unless they are disturbed in some manner. This unusual occurrence is partly due to the surface tension of the water droplet not allowing the droplet to expand and freeze. However, when the aircraft surfaces disturb these droplets, they immediately turn to ice on the aircraft surfaces.

The ice may have a glazed or rime appearance. The glazed ice is smooth and hard to detect visually. The rime ice is rough and easily noticed.

Frost is formed as a result of water vapor being turned directly into a solid. It can form on the aircraft surfaces in two ways. First, it can accumulate on the aircraft parked in the open overnight when the temperature drops below freezing and proper humidity conditions exist. Second, it can form on aircraft surfaces which, after flying at very cold altitudes, descends rapidly into warm, moist air. In this case, frost deposits will result before the structure warms up because of the marked cooling of air adjacent to the cold skin.

The hazards of ice or frost forming on the aircraft are the resulting malformation of the airfoil, which could decrease the amount of lift and the additional weight and unequal formation of the ice, which could cause unbalancing of the aircraft, making it hard to control.

Enough ice to cause an unsafe flight condition can form in a very short period of time, thus some method of ice prevention or removal is necessary.

Presently there are two methods for eliminating or preventing ice. One method, deicing, employs a mechanical system to break up and remove the ice after it has formed. The second method, anti-icing, uses heated bleed air to prevent the formation of ice. The deicing systems are common to older aircraft and are now generally being replaced by anti-icing systems.

DEICER BOOT SYSTEMS

The deicing system for the wing and horizontal and vertical stabilizer leading edges of the E-2 aircraft provide an example of a typical deicer boot type system. The system removes accumulated ice from the leading edge surfaces by inflating and deflating rubber deicer boots, which are bonded to the leading edges.

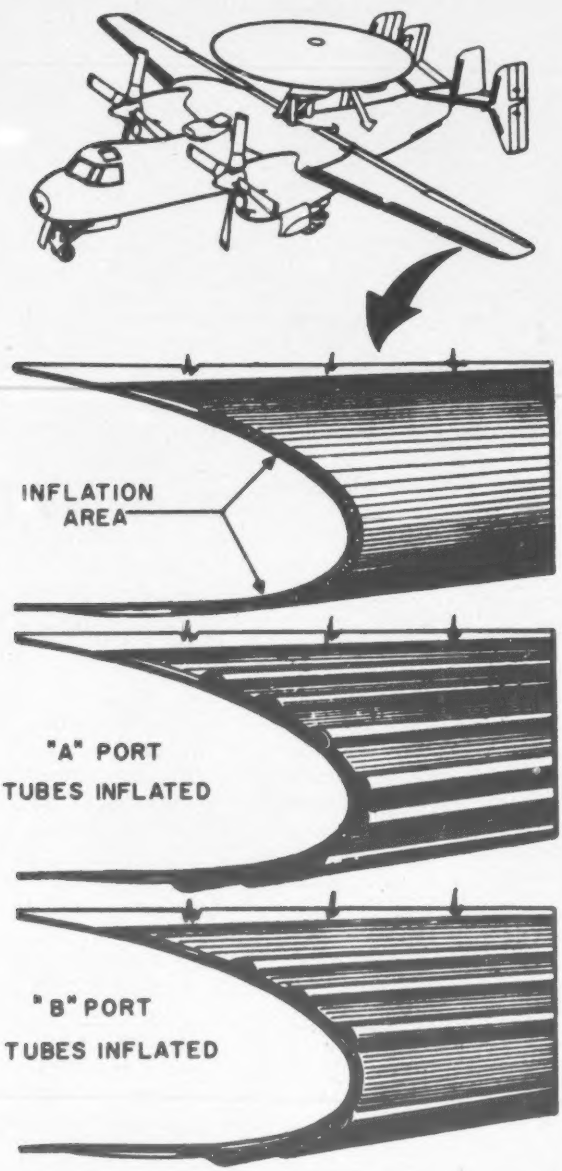
The cells or tubes of the deicer boots (fig. 6-16) are inflated and deflated alternately by applying pressure and suction, causing a wavelike motion which cracks the formed ice and allows it to be carried away by the airstream.

The E-2A deicing system illustrated in figure 6-17 is pneumatically operated and electrically controlled. Engine bleed air provides the necessary air pressure. The bleed air is regulated by the pressure regulator and relief valve. Suction is provided by the ejector and regulated by the suction relief valve. Suction and pressure gages provide a means of monitoring system suction and pressure readings which indicate proper or improper system operation.

Components

The deicer system consists of the following main components: electronic timer, three distributor valves, pressure regulator and relief valve, ejector, suction relief valve, the deicer boot sections, and pressure and suction gages.

ELECTRONIC TIMER.—The timer controls the inflation and deflation of the deicer boots by alternately energizing and deenergizing the



AM.1152
Figure 6-16.—Deicer boot location/operation.

the solenoids of the distributor valves in a specific sequence. Pressure and suction are applied to the boots in the following sequence: the inboard wing boots, the outboard wing boots, the outboard stabilizer and vertical fin boots, and the inboard stabilizer and fin boots.

Each group of boots is inflated for approximately 5 seconds, and the succeeding group begins inflating approximately 10 seconds after the first group begins deflating. The total time for the complete inflation cycle to all four boot groups is approximately 1 minute. The timer is a sealed unit and is maintained by personnel in the AE rating.

DISTRIBUTOR VALVES.—Each of the deicing system's three distributor valves (fig. 6-17) has a pressure inlet port, a suction inlet port, two outlet ports to the deicer boots, and an exhaust port. The exhaust port routes air returning to the distribution valve in the deflation cycle, overboard to a low-pressure area. The low-pressure exhaust area creates a slight suction to assist in deflation of the boot.

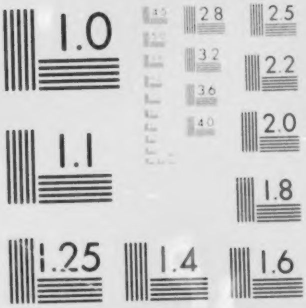
The pressure inlet port is connected to the engine bleed-air mainfold pressure line. The suction port is connected to the main suction line from the ejector. Approximately 4 in. Hg suction is available at all times to the distributor valves.

Each distributor valve has two solenoids which, when energized, allow air pressure to inflate their respective boot tubes as was shown in figure 6-16. When the solenoids are deenergized, the valves allow suction to be applied to the boots, holding them down (deflated) in flight.

When the deicing system is operating and one of the solenoids is energized by an electrical signal from the electronic timer, it causes the distributor valve servo controlled by that solenoid to change the inlet to the boots from suction to pressure. The boot tubes served by that outlet will inflate for the predetermined time interval controlled by the timer.

When the solenoid is deenergized, air from the boot tubes flow through an integral check valve in the distributor valve and out the exhaust port until the pressure drops to approximately 1 in. Hg. At this time the boot is again ported to the suction manifold, through the distributor valve, and any remaining air is evacuated, fully collapsing the boot tubes as illustrated in figure 6-16.

PRESSURE REGULATOR AND RELIEF VALVE.—This valve converts the uncontrolled bleed air to a regulated air pressure of approximately 18 psi and routes it to the three distributor valves and the pressure gage.


1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

seat. When the predetermined outlet pressure is reached, the inlet valve is fully seated, shutting off the flow of bleed air through the valve. When the downstream pressure drops below the regulator setting, it reduces the air pressure under the diaphragm and the regulating spring forces the inlet valve off its seat, allowing inlet air to restore the system operating pressure.

The relief valve section of the valve is held in the seated position by spring pressure until the air pressure in the outlet port exceeds a predetermined safe value.

In the event that the regulator diaphragm ruptures or the regulating portion of the valve fails for any reason, the relief valve can function as a pressure regulator as well as a relief valve to temporarily protect the downstream deicer system components from excessive pressure.

EJECTOR.—The ejector unit consists of a pressure port, a venturi, an overboard port, and a suction port. As air pressure from the pressure manifold enters the inlet pressure port, it creates the necessary suction at the suction port and in the main suction line to the distributor valves for deflating the deicer boots.

SUCTION RELIEF VALVE.—The suction relief valve installed in the suction manifold lines leading from the ejector to the tail section distributor valve regulates deicing system suction. When suction in the manifold lines becomes excessive, the spring tension that seats the relief valve is overcome and the valve opens to permit compartment air into the suction manifold lines until the suction pressure is reduced to approximately 6 in. Hg.

An adjusting nut on the relief valve is used to adjust the tension on the spring that seats the relief valve. "On aircraft" adjustment is generally prohibited.

DEICER BOOTS.—The rubber deicer boots (fig. 6-16) are attached to the leading edge surfaces with cement or fairing strips and screws, or a combination of both. On the E-2A, they are bonded to the leading edges with cement and tapered slightly to provide a smooth airflow over the boot and wing, when the boots are deflated.

Removal, installation, and repair of the deicer boots are the responsibility of personnel in the AMS rating.

PRESSURE GAGE.—The deicing system cockpit-mounted pressure gage indicates the pressure available for inflating the deicer boots when the system is operating. The gage is calibrated from 0 to 20 psi in 1-inch increments. Normal system operation is indicated by a slight pressure fluctuation of the pointer. This fluctuation is caused by a momentary drop in pressure at the beginning of each inflation period for each deicer boot group. A steady reading of 18 psi on the gage indicates a nonoperating condition.

SUCTION GAGE.—The deicer system cockpit-mounted suction gage indicates the suction available for deflating the deicer boots. The 0 to 10 in. Hg gage is calibrated in major increments of 1 in. Hg and minor increments of 0.2 in. Hg. Slight pointer fluctuation indicates proper system operation as was the case with the pressure gage. A steady reading of 6 in. Hg on the gage indicates a nonoperating condition.

Maintenance

As was previously indicated, maintenance of deicer boot systems is normally performed by personnel of the AMS, AE, and AME ratings.

Personnel of the AMS rating are primarily concerned with the removal, installation, and miscellaneous repairs of the deicer boots. AE personnel are concerned with removal, replacement, and repair of deicer system electrical components.

The AME is generally responsible for all other components of the deicer system, AME personnel assigned to the Organizational level of maintenance are responsible for removal and replacement of malfunctioning components, maintenance of associated plumbing, and rendering of assistance to senior personnel in the performance of operational checkouts and troubleshooting.

Some steps of the operational check, as outlined in the applicable Maintenance Instructions Manual, are performed utilizing external electrical power and an external air supply. The air supply is connected to the bleed-air line test connection and must be capable of supplying a pressure of 50 to 90 psi. Remaining steps of the operational checkout requires that one of the aircraft's engines be started.

NOTE: Personnel turning up naval aircraft must be fully qualified, designated in writing, and carry a current turnup card in accordance with OpNav 4790.2 (Series) Instruction.

All steps of the operational checkout must be performed in the sequence outlined in the

MIM. When a trouble occurs during a step, it must be corrected before proceeding to the next step.

Troubleshooting, removal and replacement of components, and the operational checkout should always be accomplished in accordance with the specific instructions provided in the applicable Maintenance Instructions Manual with appropriate emphasis on quality workmanshop and inspection.

AME personnel assigned to the Intermediate level maintenance activity (AIMD) will become involved in miscellaneous component repair of select deicer components as indicated in the Component Repair Section (IV) of the MIM. Instructions in this section of the MIM include a list of replacement parts and cure date kits, etc., available to the Intermediate level of maintenance, consumable materials, support equipment, and manpower requirements necessary to accomplish limited repair.

Repair of components involves partial or complete disassembly, cleaning, inspection, repair and parts replacement, reassembly, and testing. Quality assurance during repair of the components is mandatory at specified steps to verify proper inspection, assembly, and testing. Quality assurance steps in the MIM are underlined, italicized, or identified in some other conspicuous manner specified in the instructions for using that particular MIM.

BLEED-AIR ANTI-ICING SYSTEM

The wing anti-icing system of the P-3 aircraft provides a typical example of a hot wing anti-icing type system. The system utilizes hot compressed bleed air from the aircraft's engines to prevent ice formation on the leading edges of the wings only.

The system illustrated in figure 6-18 can also be considered a deicing system in that it will also remove ice formed on the aircraft on the ground. In flight the aircraft ice detector system warns the pilot of icing conditions so that he may take appropriate action.

Description/Operation

The hot engine bleed air utilized in the wing anti-icing system is ducted from two ports on the 14th stage of each of the aircraft's four engines. The airflow is orifice regulated to maintain a fixed percentage of engine airflow for all flight altitudes and speeds.

Airflow from the two ports of each engine is ducted through common check valves to a bleed-air nacelle shutoff valve located aft of the 14th stage engine firewall. Ducting from this shutoff valve connects to a common cross-ship ducting assembly.

The engine nacelle bleed-air shutoff valve serves the dual purpose of permitting passage of anti-icing air in one direction to the cross-ship ducting and allows engine starting airflow to pass in the opposite direction for starting the engine. It is a butterfly type, normally closed valve, which is opened only for the two previously stated circumstances. The valve will automatically close during engine emergency shutdown, regardless of the control switch position. The valve butterfly is fitted with two piston rings, similar to automotive piston rings, to compensate for expansion and contraction of valve parts, thus preventing binding while still maintaining proper sealing characteristics.

Electrical controls for the various valves in the ice protection (anti-icing) systems are located on the aircraft's ice protection overhead panel. The panel illustrated in figure 6-19 is located on the flight station (cockpit) overhead.

The fuselage bleed-air shutoff valve, one in each wing, isolates the wing ducting from fuselage ducting as well as one wing duct section from the other.

A drain valve is provided in the fuselage crosship manifold section for draining any condensation in the system caused by high humidity conditions. Operation of the valve is automatic. It will open when the duct-to-ambient air pressure differential is between 0 and 2 psi and close at a differential of 5 psi and above.

The temperature of the wing leading edge is controlled by the amount of air passed through the ejector assemblies by the anti-icing modulating valves. An ejector assembly manifold tube and a typical hot wing construction view are provided in figure 6-20 and 6-21.

Pneumatic thermostats control the six modulating valves located throughout the anti-icing system. One valve accommodates each of the inboard, center, and outboard sections of each wing leading edge. Therefore, the temperature of each wing section is individually controlled.

Components

WING ANTI-ICING (MODULATING) VALVE.—The six modulating valves maintain a constant

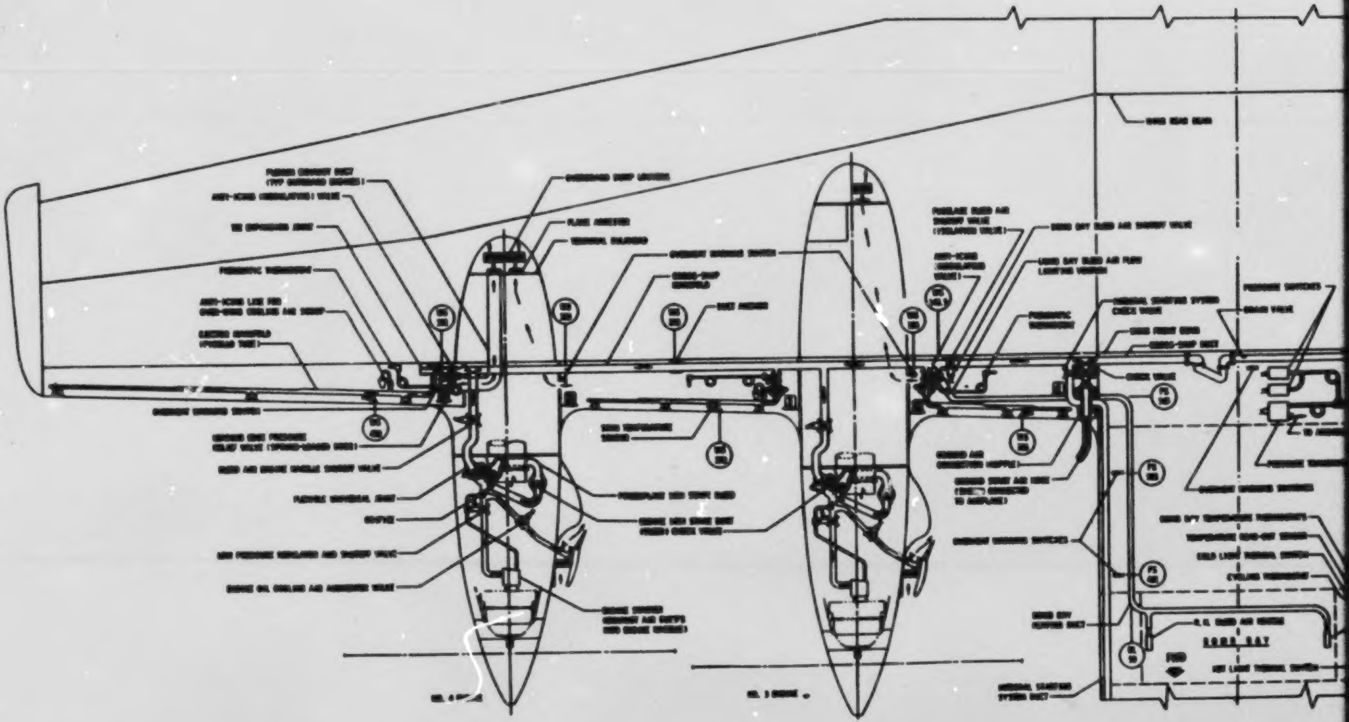

BOMB BAY
FWD

Figure 6-18.—Wing anti-icing and bomb bay heating system—P-3A.

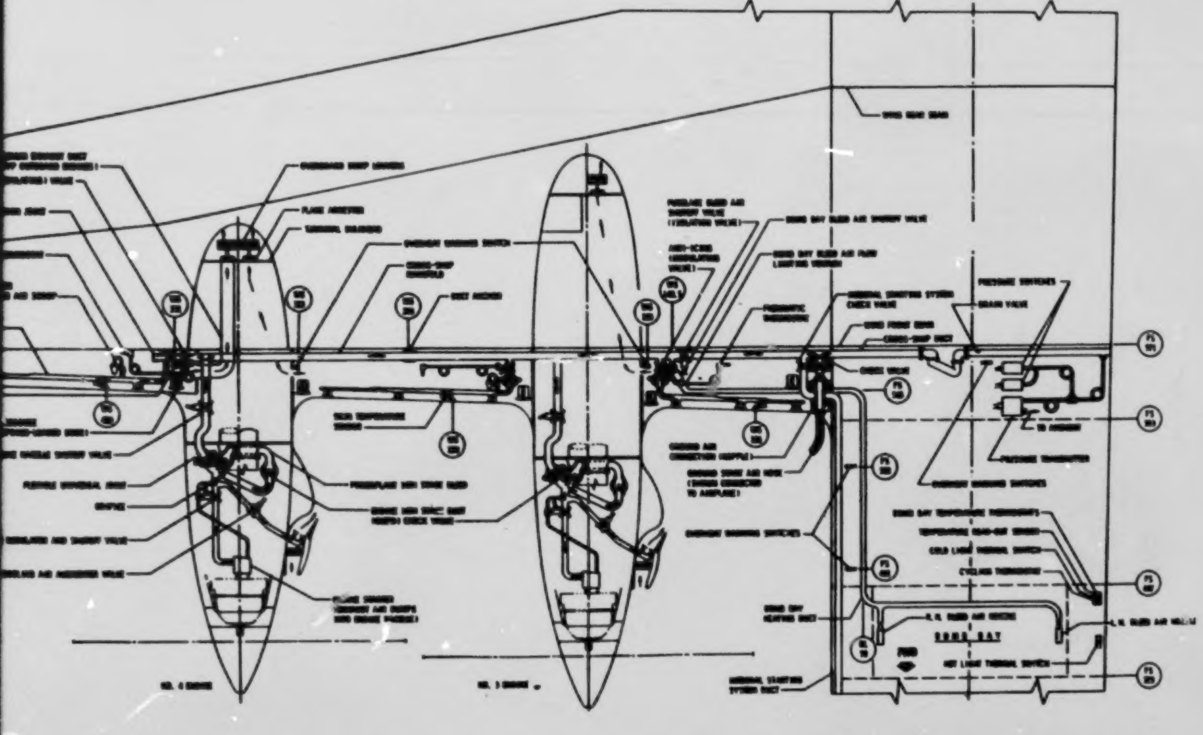

CHECK VALVE
DRAIN VALVE
PRESSURE SWITCHES
PRESSURE TRANSMITTER
OVERHEAT WARNING SWITCHES
BOMB BAY

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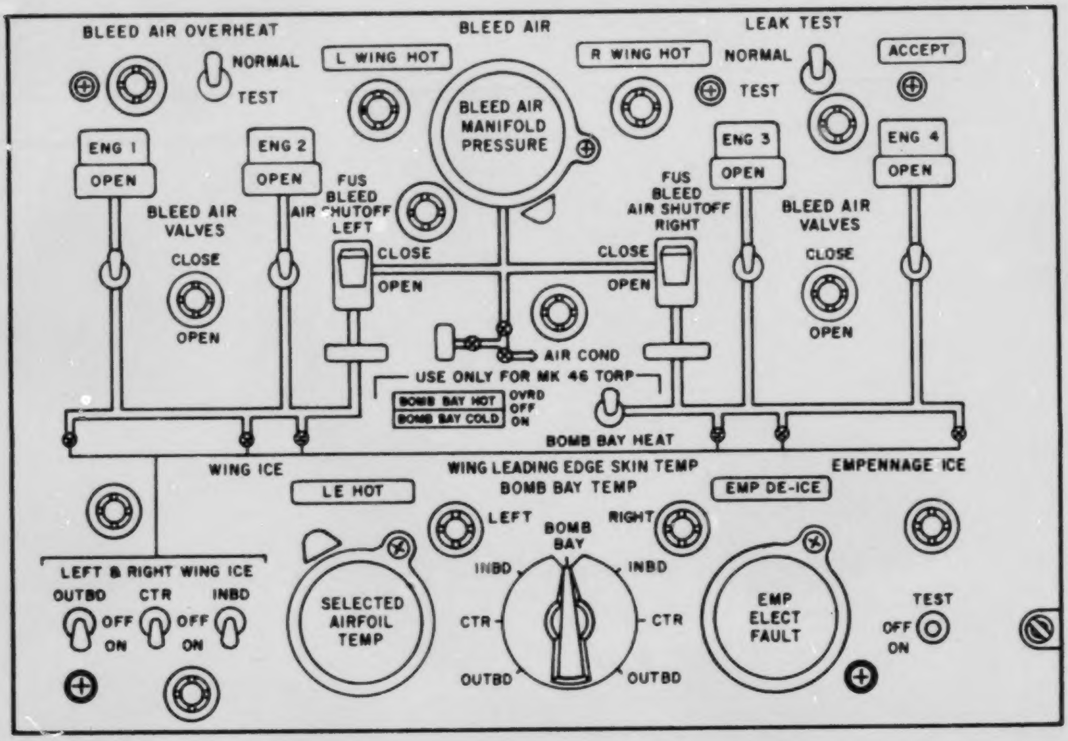
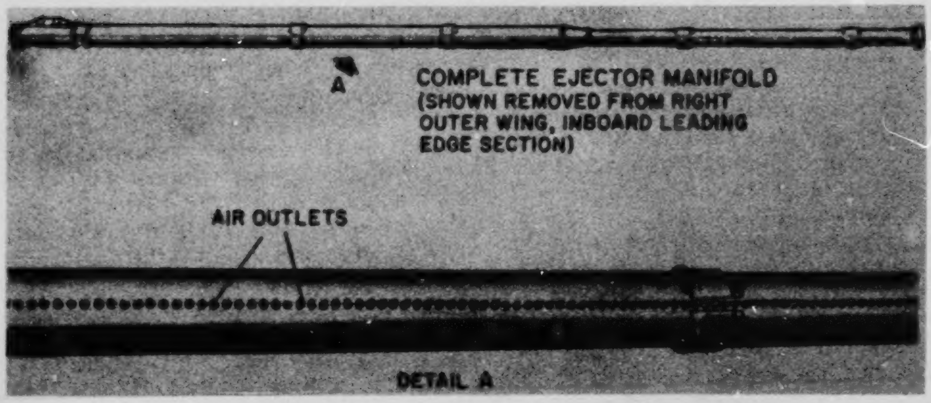
Figure 6-18.—Wing anti-icing and bomb bay heating system—P-3A.


BLEED AIR OVERHEAT
NORMAL
TEST
BLEED AIR
L WING HOT
R WING HOT
LEAK TEST
NORMAL
TEST
ACCEPT
BLEED AIR MANIFOLD PRESSURE
ENG 1
OPEN
ENG 2
OPEN
ENG 3
OPEN
ENG 4
OPEN
BLEED AIR VALVES
CLOSE
OPEN
FUS BLEED AIR SHUTOFF LEFT
FUS BLEED AIR SHUTOFF RIGHT
CLOSE
OPEN
BLEED AIR VALVES
CLOSE
OPEN
AIR COND
USE ONLY FOR MK 46 TORP
BOMB BAY HOT
BOMB BAY COLD
OVRD
OFF
ON
BOMB BAY HEAT
WING ICE
WING LEADING EDGE SKIN TEMP
BOMB BAY TEMP
EMPENNAGE ICE
LE HOT
EMP DE-ICE
LEFT
RIGHT
BOMB BAY
INBD
CTR
OUTBD
INBD
CTR
OUTBD
LEFT & RIGHT WING ICE
OUTBD
CTR
INBD
OFF
ON
OFF
ON
SELECTED AIRFOIL TEMP
EMP ELECT FAULT
TEST
OFF
ON

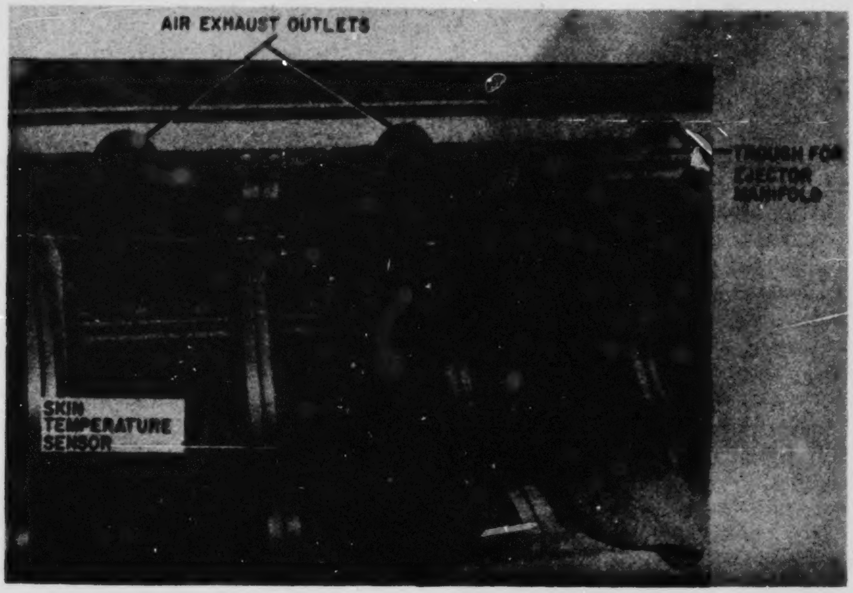
AM.1155

Figure 6-19.—Ice control and protection panel.


A
COMPLETE EJECTOR MANIFOLD (SHOWN REMOVED FROM RIGHT OUTER WING, INBOARD LEADING EDGE SECTION)
AIR OUTLETS
DETAIL A

AM.1156

Figure 6-20.—Ejector manifold tube assembly.



AM.1157

Figure 6-21.—Hot wing construction view-leading edge.

bleed-air temperature for anti-icing and act as shutoff valves when anti-icing is not required. The valves are electrically controlled by switches on the ice control and protection panel and modulate in response to temperature and pressure changes detected by the wing leading edge pneumatic thermostats. A cross-sectional view of the wing leading edge and the anti-icing valve and the manner in which the leading edge components are installed are provided in figure 6-22.

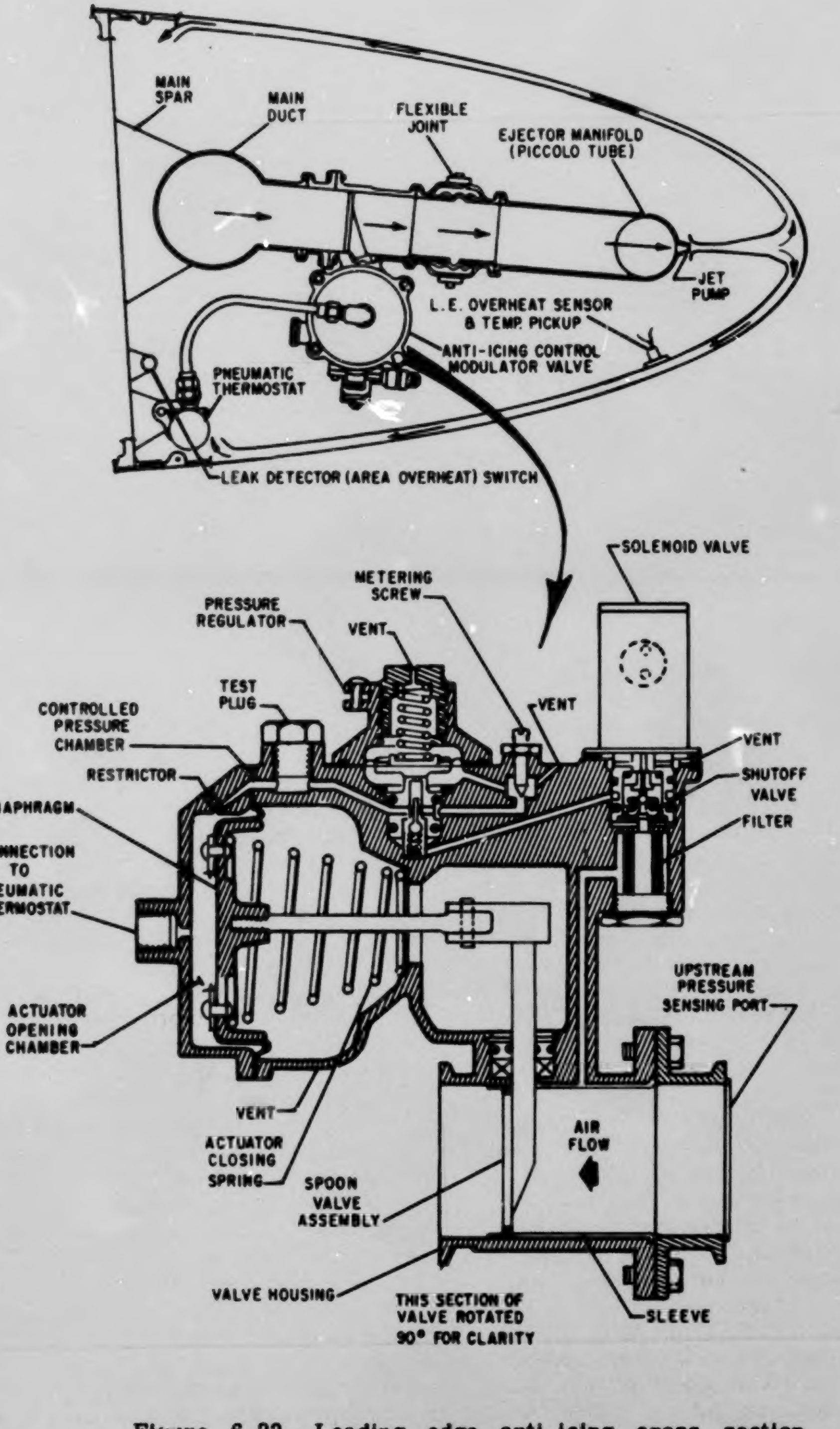
Each valve has a solenoid valve which, when energized admits bleed air from the upstream sensing port, through the filter and pressure regulator to the unvented side of the valve diaphragm. The vented side of the diaphragm is spring loaded to close the valve. When air pressure is admitted to the unvented side of the diaphragm, the increase in chamber pressure causes the valve spoon assembly (butterfly) to open and admit air into the particular ejector tube assembly section.

An increase in air temperature in that section causes the pneumatic thermostat for that section to open a bleed passage from the diaphragm chamber of the modulating valve, thus reducing pressure and allowing the actuator closing spring to modulate the valve towards the closed position. The valve will continually modulate to maintain a condition of balance between airflow and temperature.

PNEUMATIC THERMOSTAT.—The pneumatic thermostat shown in figure 6-23 is composed of a probe and valve sections. The probe housing contains a core made of high and low expansion materials which attach to a sliding piston. The piston contains an override spring and a ball type metering valve. Airflow over the core material causes the core material to expand or contract, depending on the temperature of the air. As the temperature around the core material rises, the core pulls the piston and metering ball off the seated position, allowing the unvented side of the modulating valve diaphragm to be vented to ambient. The higher the temperature the larger the bleed opening until the modulating valve completely closes. As the modulating valve approaches the closed position, the airflow decreases and the temperature drops.

The thermostats located in the outboard wing section of each wing are set to maintain a temperature of approximately 145° F. The inboard and center section thermostats maintain a temperature of approximately 120° F.

EJECTOR MANIFOLD.—The ejector manifolds are mounted in a trough in the wing leading


MAIN SPAR
MAIN DUCT
FLEXIBLE JOINT
EJECTOR MANIFOLD (PICCOLO TUBE)
JET PUMP
L.E. OVERHEAT SENSOR & TEMP. PICKUP
ANTI-ICING CONTROL MODULATOR VALVE
PNEUMATIC THERMOSTAT
LEAK DETECTOR (AREA OVERHEAT) SWITCH
SOLENOID VALVE
METERING SCREW
PRESSURE REGULATOR
VENT
TEST PLUG
VENT
CONTROLLED PRESSURE CHAMBER
VENT
RESTRICTOR
SHUTOFF VALVE
DIAPHRAGM
FILTER
CONNECTION TO PNEUMATIC THERMOSTAT
UPSTREAM PRESSURE SENSING PORT
ACTUATOR OPENING CHAMBER
VENT
AIR FLOW
ACTUATOR CLOSING SPRING
SPOON VALVE ASSEMBLY
VALVE HOUSING
THIS SECTION OF VALVE ROTATED 90° FOR CLARITY
SLEEVE

AM.1158

Figure 6-22.—Leading edge anti-icing cross section.

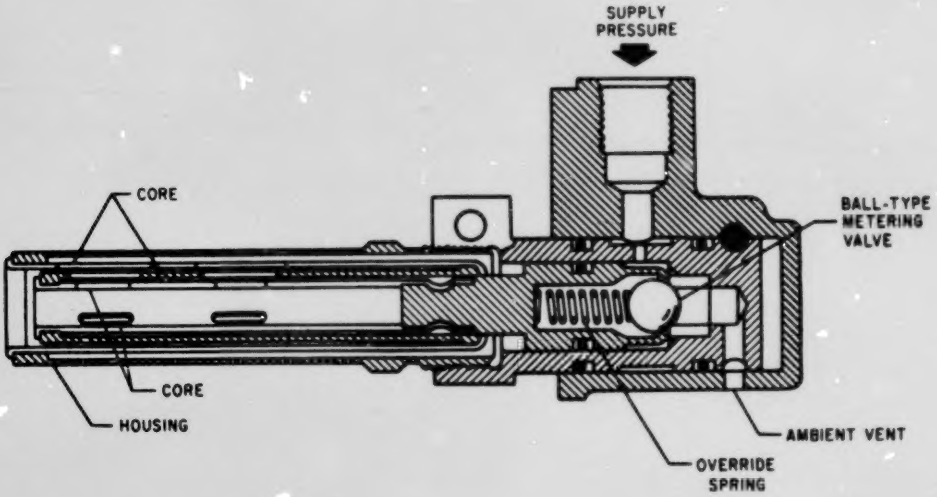


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Figure 6-23.—Pneumatic thermostat.

edge as illustrated in figure 6-21. Their purpose is to evenly distribute the hot air from the modulating valve into the wing leading edge plenum area mixing section. (See fig. 6-21 and 6-22.)

The ejector manifold is basically a stainless steel, step tapered tube with a row of jet nozzles along its entire length to direct hot air through the jet pump venturi that mixes the hot bleed air with leading edge plenum air. This mixed air is then directed into the double skin, hot air passage of the wing leading edge.

The small end of the ejector is anchored to the wing structure to prevent rotation. The remaining length of the ejector is supported at each rib by clamps which permit longitudinal motion to compensate for tube expansion and contraction.

PRESSURE RELIEF VALVE.—Five spring-loaded doors are built into the lower fillet area of each wing to act as pressure relief valves. The spring tension holds the doors closed until overcome by wing leading edge pressure. When anti-icing pressure within the wing reaches approximately 5 psi, the door opens slightly to relieve pressure overboard.

TEMPERATURE INDICATING AND OVERHEAT WARNING COMPONENTS.—Temperature sensors located in each wing section will illuminate a caution light on the ice control and protection panel if the skin temperature increases beyond 230° F at any one of the sensor locations. The wing temperature rotary switch (fig. 6-19) can then be used to select the various sensor positions and thus provide a means of checking the temperature of the skin at each individual sensor location. The temperature is indicated on the indicator gage adjacent to the selector switch. The sensor units are capable of sensing temperatures ranging from 0° to 350° F.

Three thermal switches and nine bleed-air overheat warning switches throughout the anti-icing system provide the pilot with a caution light indication of improper system operation (out of limits temperature).

EMPENNAGE ANTI-ICING/DEICING.—The empennage anti-icing and deicing system of the P-3 is a completely electrical system utilizing electrical heating element parting strips to prevent or remove ice. Both the horizontal and vertical surface leading edges are protected in this manner. Since the electrical system is the responsibility of personnel in the AE rating, no coverage is provided in this manual.

Maintenance

The leak test switch located on the ice control and protection panel is used to determine whether leakage in the anti-icing system is within acceptable limits. Excess leakage can be caused by leakage at system valves or ducting connections. With the aircraft engines running, the anti-icing system is pressurized to perform the leak test as follows:

1. Utilizing the switches on the control panel (fig. 6-19), open the No. 4 engine bleed-air valve and close the other three bleed-air valves.
2. Keep the No. 4 bleed-air valve open until the bleed manifold gage on the panel indicates 27 psi, then move the switch to the closed position.
3. Press the test switch. Pressure on the manifold gage will drop and if after 8 seconds delay the system is acceptable, the leak test ACCEPT light will illuminate. The light will go out when the test switch is released.

Organizational level maintenance consists of isolation, removal, and replacement of malfunctioning components and performing of operational checkouts. Complete troubleshooting and component removal and replacement procedures are provided in the Maintenance Instructions Manual.

Intermediate level maintenance is allowed on some of the system valves that are inoperative or that allow excessive internal leakage. Section IV of the MIM provides detailed procedures for performing component repair. Instructions for the disassembly, cleaning, inspection, repair and replacement of parts, assembly, and testing of components not covered in Section IV of the applicable MIM will normally be provided in a NavAir 03 series publication.

During all phases of Intermediate level repair, insure that adequate attention is given to quality workmanship and inspection by qualified personnel.

BOMB BAY HEATING SYSTEM

In order to provide for the environmental control necessary to insure proper operation of designated naval weapons, some aircraft (such as the P-3) are equipped with a bomb bay heating system.

In the P-3, heating of the bomb bay is required under certain conditions when the MK-46 torpedo is being carried. The heating system is designed to provide automatic heat regulation with visual temperature monitoring, as well as overheat and below operational temperature warnings.

DESCRIPTION

Bleed air used to heat the bomb bay is tapped from the right-hand leading edge anti-icing manifold as illustrated in figure 6-18. The bomb bay duct runs aft of the inboard ejector duct until it enters the fuselage, where it runs forward on the right side. The duct also extends over the upper aft end of the bomb bay to provide a more even distribution of air on both sides of the bay.

The hot air exits the bomb bay ducting through the two bleed-air ejector nozzles. The nozzle construction causes the hot air to be mixed with the bomb bay ambient air and discharges the air forward and slightly downward along the bay side panels in such a manner that minimum heat is transferred to the panel structure. The mixing action created by the nozzles reduces the bleed-air temperature and promotes effective circulation throughout the bomb bay area.

Heating is manually initiated by the flight engineer utilizing the bomb bay heat switch located on the overhead anti-icing control panel (fig. 6-19). Once this switch is positioned, the heat in the area will be automatically maintained between 30° and 45° F by the cycling thermostat (fig. 6-18).

OPERATION

When the wing leading edge skin temperature selector switch (located on the anti-icing control panel) is in the BOMB BAY position and the temperature in the bomb bay drops below 25° F, a bomb bay cold indicator and the deicing master caution lights in the cockpit will illuminate. In response to this situation, the flight engineer must manually position the bomb bay heat switch to ON, the right-hand bleed-air shutoff valve to CLOSE, and the No. 3 and No. 4 engine bleed air switches to OPEN. This permits hot bleed air to enter the wing leading edge ducting between the fuselage bleed-air shutoff (isolation) valve, the anti-icing modulating valves, and the remaining engine bleed-air valve. Positioning the bomb bay heating switch to ON opens the bomb bay bleed-air shutoff valve and allows hot bleed air to flow through the airflow limiting venturi and into the fuselage ducting for ultimate distribution in the bomb bay area.

As long as these conditions prevail, the bomb bay bleed-air shutoff valve will cycle open to closed as directed by responses received from the cycling thermostat.

If the cycling thermostat fails, the bomb bay heat switch can be placed in the OVRD (override) position and the bomb bay temperature manually controlled, utilizing the override position and monitoring the various system temperature and caution lights. When the wing leading edge temperature selector switch is in the bomb bay position, the bomb bay temperature will be indicated on the selected airfoil temperature indicator.

MAINTENANCE

Maintenance of the bomb bay heating system is similar to that allowed on the wing anti-icing system. Maintenance consists of operational checks and removal and replacement of faulty components and associated plumbing.

Electrical components of the system are the responsibility of personnel in the AE rating. As previously mentioned in this manual, malfunctions that involve more than one rating (AME and AE) will require joint cooperation if troubleshooting, isolating, and correcting of the malfunction it to be accomplished in an efficient manner.

FIRE EXTINGUISHING SYSTEMS

As a general rule, fire extinguishing systems are incorporated only in multiengine aircraft. These systems are designed primarily for extinguishing engine fires; however, on some aircraft, provision is made for protecting the aircraft heater (or heaters), as well as the engines.

The extinguishing agent is stored in cylinders mounted at various places within the fuselage, wings, nacelles, or landing gear wells, and is directed to the area of fire through a system of tubing and various control valves. A switch or pull handle, located at the pilot's or flight engineer's station, is used in releasing the extinguishing agent when a fire occurs.

The inspection and maintenance of aircraft fire extinguishing systems is another one of the important responsibilities of the AME.

TYPES OF EXTINGUISHING AGENTS

There are a number of fire extinguishing agents; however, the two most commonly used in aircraft systems are carbon dioxide (CO_2) and trifluorobromomethane (CF_3Br). Trifluorobromomethane is also referred to as bromotrifluoromethane; either is correct.

Carbon Dioxide (CO_2)

Carbon dioxide is a colorless, odorless, and tasteless gas under normal conditions of atmospheric pressure and temperature. Liquid carbon dioxide exists only under pressure. When released to atmospheric pressure, it immediately turns into a mixture of solid carbon dioxide snow and vapor, depending upon storage temperature and release temperature. At the instant of release, the discharge appears as a white fog.

Carbon dioxide is an inert gas which makes it a valuable extinguishing agent and which acts with almost instantaneous smothering effect. Carbon dioxide is an electrical insulator and is nondamaging to most materials. It is noncorrosive, leaves no residue, and does not deteriorate with age.

Trifluorobromomethane (CF3Br)

CF_3Br (the chemical symbol for trifluorobromomethane) is a newly developed fluorinated hydrocarbon which is more efficient than CO_2 as a fire extinguishing agent. CF_3Br, like CO_2 is a colorless, odorless, and tasteless gas under normal atmospheric pressure and temperature, and exists as a liquid only when under pressure. CF_3Br is nontoxic. It is an electrical insulator, is noncorrosive, leaves no residue, does not deteriorate with age, and goes farther than CO_2.

NOTE: CF_3Br is often referred to by the trade name, Freon 13B1.

Only the CF_3Br system will be discussed in this chapter.

TRIFLUOROBROMOMETHANE (CF_3Br) SYSTEM

Figure 6-24 illustrates a typical trifluorobromomethane fire extinguishing system. The system consists of a container assembly, distributing tube assemblies, and the necessary tubing and electrical equipment.

System Operation

To activate the system shown in figure 6-24, the fluid cutoff handle for the affected engine is pulled. This action turns off the combustible fluids, feathers the propeller, and shuts down the engine. Pulling this handle exposes the fire extinguisher switch. Pressing the fire extinguisher switch completes the electrical circuit necessary to detonate the explosive charge in the bonnet assembly of the container (fig. 6-25). This explosive charge ruptures the frangible disc in the container and allows the extinguishing agent to flow into the engine nacelle. The fluid (CF_3Br) discharges from the distributing assembly as a spray, which (in the presence of heat) turns into a dense gas. This gas reduces the oxygen content of the area and effectively smothers the fire.

System Components

CONTAINER ASSEMBLY.—Each container assembly (fig. 6-25) consists of the following components: A fusible plug, pressure gage, frangible disc, cartridge, bonnet, and the container itself. The container is a spherical assembly, designed to contain 6.5 pounds of CF_3Br and a precharge of 600 psi of nitrogen at (70° F). NOTE: The capacity and precharge of the container assembly will vary with the type of installation.

The combined nitrogen charge and CF_3 Br is retained in the container by the frangible disc and the fusible plug. The disc shatters upon impact by a slug from the cartridge, releasing the contents of the container into the fire area.

Where there is an increase in ambient temperature, the fusible plug protects the container from possible damage by excess pressure. The metal of the fusible plug melts at temperature between 208° and 220° F, releasing the contents of the container overboard.

The operation of the container is as follows: When the fire extinguisher switch is pressed, an electrical current ignites the explosive in the cartridge. A slug is then propelled from the cartridge and strikes the frangible disc. The impact of this slug shatters the disc and releases the contents of the container. The 600 psi nitrogen precharge expels the CF_3Br. The strainer in the bonnet (fig. 6-25) prevents the segments of the shattered disc from being expelled into the distributing assembly.

DISCHARGE INDICATOR.—One discharge indicator is mounted on each nacelle as shown in figure 6-24. The indicator consists of a red disc and an aluminum alloy tube which connects to the container at the fusible plug. If thermal expansion in the container is great enough to rupture the fusible disc, the red disc will rupture and the CF_3Br will flow overboard through the line to the indicator. Therefore, when the discharge indicator is found missing, the container must be checked for proper pressure.

Some CF_3Br containers have a relief valve in place of the fusible plug. On some the fusible plug is referred to as a safety plug. The relief valve relieves the excess pressure in the container instead of completely emptying the container.

NOTE: Some larger aircraft utilize more than one fire extinguishing agent container to direct the agent to several points within an area. With cockpit switches set at various positions, the agent can be released through specific discharge outlets; and if the fire persists, the switch positions can be changed to release agent from a second container to different discharge outlets within the same area.

The fire extinguishing system of the P-3 aircraft provides an example of this type system. The containers utilized in the P-3 system are also equipped with two valve (bonnet) assemblies for discharging the container; however, only one assembly is fired at any one time to discharge the container. This dual arrangement provides for a secondary means of discharging a cylinder in the event a cartridge fails to fire and discharge the container for any reason.

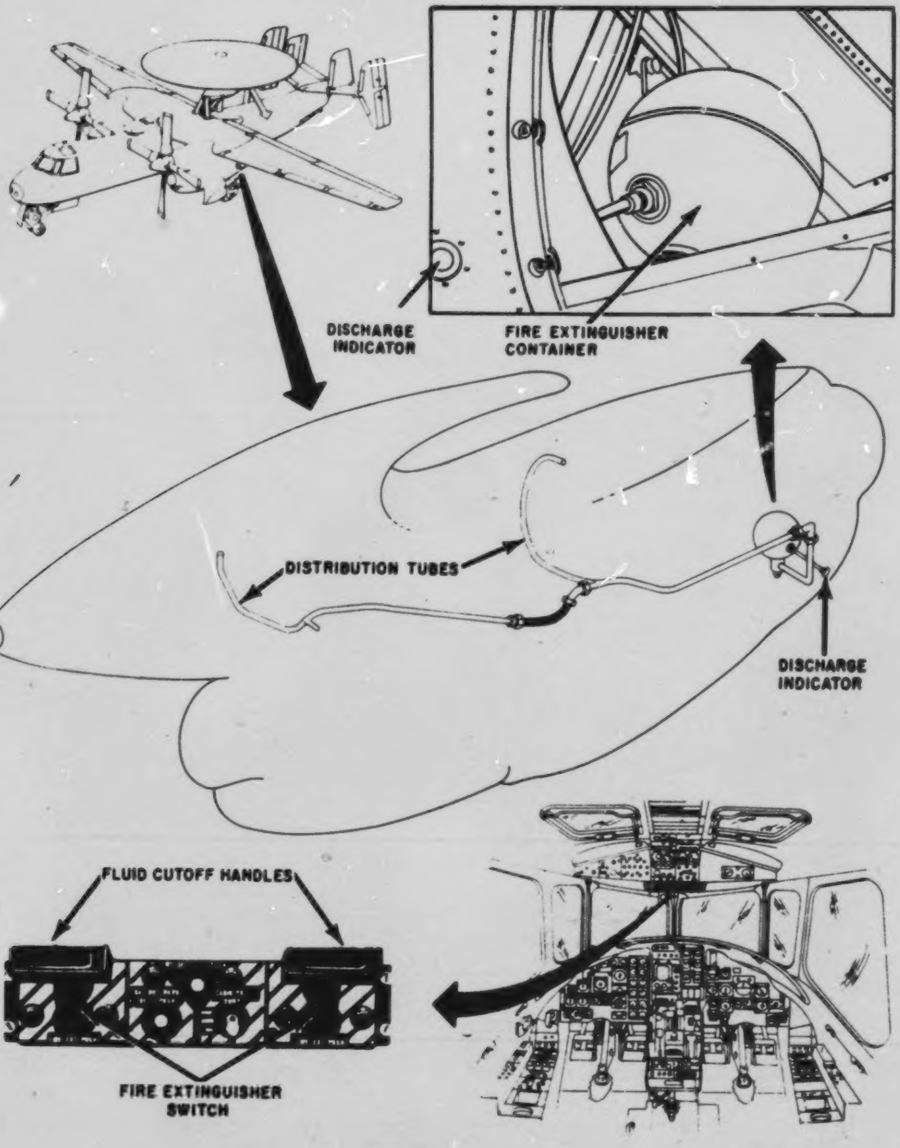
Maintenance

Maintenance of the CF_3Br fire extinguishing system at the Organizational level of maintenance consists of replacement of faulty components and discharged or below pressure containers, maintenance of associated plumbing, and the performing of operational checks.

Containers should be replaced when the pressure falls below that indicated on the container or in the applicable Maintenance Instructions Manual. A gage on each container indicates the pressure therein. A suspected leakage in system plumbing will require disconnecting of the container (s) and pressure leakage testing of all lines utilizing nitrogen pressure and a leakage tester. The leakage tester provides a means of measuring the pressure drop over a specified period of time as outlined in the MIM.

The operational checkout of the fire extinguishing system is primarily a checkout of electrical circuitry, such as wiring continuity checks, proper switch operation, etc., which is performed by personnel of the AE rating.

Intermediate level maintenance of components of concern to the AME consists of disassembly, cleaning, inspection, miscellaneous repair and parts replacement, recharging, and testing of the fire extinguishing container. A listing a parts replaceable at the Intermediate


DISCHARGE INDICATOR
FIRE EXTINGUISHER CONTAINER
DISTRIBUTION TUBES
DISCHARGE INDICATOR
FLUID CUTOFF HANDLES
FIRE EXTINGUISHER SWITCH

AM.113

Figure 6-24.—Typical CF_3Br fire extinguishing system.

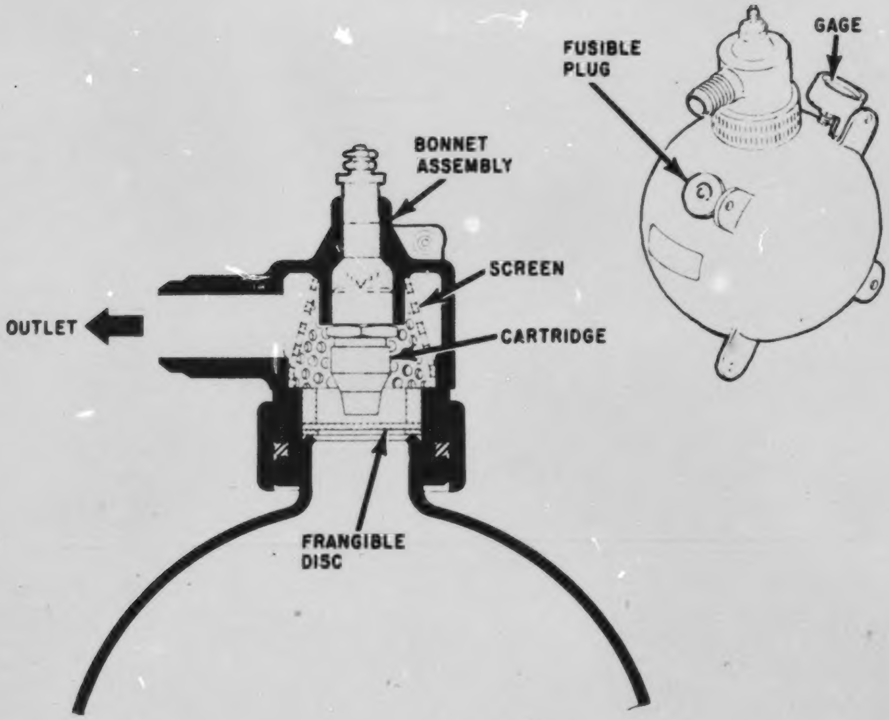


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Figure 6-25.—CF_3Br container assembly.

(AIMD) level of maintenance and special support equipment as well as step-by-step repair procedures is provided in the Component Repair section (IV) of the Maintenance Instructions Manual.

The container should be recharged immediately following repair and bench testing. Recharging of a container consists of the following general steps:

1. Install a recharging bonnet (fitting) in the safety plug port and connect to the cylinder recharging equipment.
2. Pump a vacuum on the container to completely evacuate it.
3. Charge the container with the specified volume of fire extinguishing agent, by weight.
4. Allow the container and its contents to stabilize to the temperature of the ambient air, then add nitrogen to attain the proper charging pressure in accordance with the pressure/temperature charging graph supplied in the MIM.

NOTE: As the nitrogen pressure is being applied, the container should be agitated to allow complete absorption of the nitrogen by the fire extinguishing agent.

5. Tighten the safety plug, remove the recharging bonnet, and install the safety plug valve protection plug.

The cartridge should not be installed in the valve assembly until the assembly is ready for installation on the container. A metal date tag must be attached to the container valve assembly, indicating the cartridge date. The service life and replacement criteria for the cartridge is provided in the applicable MIM and/or NavAir 11-100-1.

If the container is not being installed on an aircraft immediately, it should be properly stored. The cartridge should be removed from the bonnet and stored in accordance with all existing directives. The temperature in the cartridge storage area should not exceed 70° F. The container should be stored in a reasonably cool, well-ventilated area with the discharge port facing up. The storage area should be one that is not normally occupied by personnel.

To eliminate the possibility of cartridge malfunction, cartridges should not be interchanged between containers. The contact point between the soldered contact of previously installed cartridges and the valve can become slightly indented or mated to each other, and installation in another container valve assembly could result in a no electrical connection situation. Always use the correct cartridge designated for use with the high rate discharge containers. Use of a substitute cartridge could result in an inadvertent firing of the cartridge during the electrical checkout of the system or failure of the system to operate when needed.

NOTE: When checking containers for pressure loss, compensation must be made for ambient temperature changes. The applicable Maintenance Instructions Manual for most aircraft using the CF_3Br fire extinguishing system contains a table of temperature conversion figures.

Safety Precautions

The following safety precautions and handling procedures should be observed when working with CF_3Br to prevent injury to personnel and damage to equipment.

NOTE: CF_3Br is very volatile, but is not easily detected by odor. It is nontoxic and can be considered to be about the same as carbon dioxide, causing danger primarily by reduction of oxygen.

1. Handle the charged containers carefully to avoid rupturing the frangible seal disc or damaging the container or gage.
2. Do not discharge containers in a confined area.
3. If the liquid has been used openly or spilled in the aircraft, ventilate the area immediately.
4. If a person has been exposed to high concentrations of the gas, medical attention should be sought.
5. Do not permit CF_3Br to come in contact with the skin: frostbite or low-temperature burns may result.
6. If leakage of fire extinguishing agent in a confined space is suspected, the agent must be allowed to thoroughly dissipate and the space ventilated prior to entering. The use of a Halide detector to verify that the space is safe to enter is recommended if there is the slightest doubt concerning a concentration of vaporized agent within the space sufficient to present a hazard.

LIFE RAFT EJECTION SYSTEMS

Life raft ejection systems are generally designed so that the raft may be ejected either manually or automatically. When the system is actuated by either of these methods, the life raft compartment door is jettisoned, and the raft is inflated by a cylinder of carbon dioxide. If the raft has been properly packed and stowed in its compartment, inflation will cause the raft to be ejected from the compartment in an upright position ready for occupancy. The raft is attached to the aircraft by a small line, called the raft painter. The painter is designed to break if the aircraft should sink before it can be disconnected.

On naval aircraft not equipped with life raft ejection systems, the rafts are located in designated storage spaces inside the fuselage compartments and near emergency exits. Lanyard or painter attachment fittings are located near these exits for securing the raft prior to launching. The rafts must be manually pushed out the exit and inflation initiated by the crewmember.

NOTE: The PR rating is responsible for inspecting, testing, equipping, and packing life rafts. However, on aircraft equipment with life raft ejection systems, the AME is responsible for installation of the raft in the aircraft and maintenance of the ejection system.

TYPICAL LIFE RAFT EJECTION SYSTEM

A typical life raft ejection system is shown in figure 6-26. Among the principal components in the system are the release handles, cables, covers, and the submersion actuation (automatic) element.

Description of Manual System

As mentioned previously, most life rafts are stowed in a covered compartment specially designed to house the raft. The raft is jettisoned by pulling the life raft release cable. The initial movement of this cable pulls the cover retaining pins—further travel (pull) of the release cable causes the contents of the life raft inflation bottle to be emptied into the raft. This positive

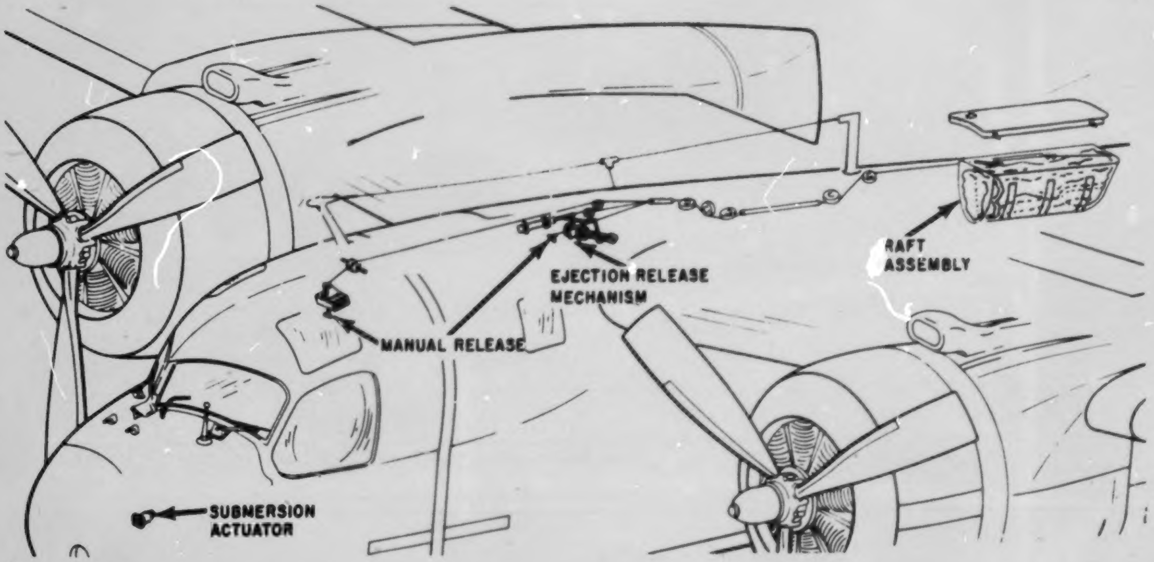


Figure 6-26.—Typical life raft ejection system.

double action is insured by rigging a little slack into the cable between the latch pin mechanism and the inflation bottle. This feature allows the cover to be removed manually without the raft inflating for routine inspection of the life raft, inflation bottle, cover assembly, and compartment condition in general.

The life raft release handles are located at various places within the aircraft near the flight stations. Regardless of how many locations the handles are placed, they are all connected to the same release cable, and a pull on any one will have the same effect on the life raft compartment door and the raft. One type of aircraft has a pull handle recessed into the top of the fuselage just forward of the life raft compartment for use in case the inside handles were inoperative and the automatic actuator failed to work.

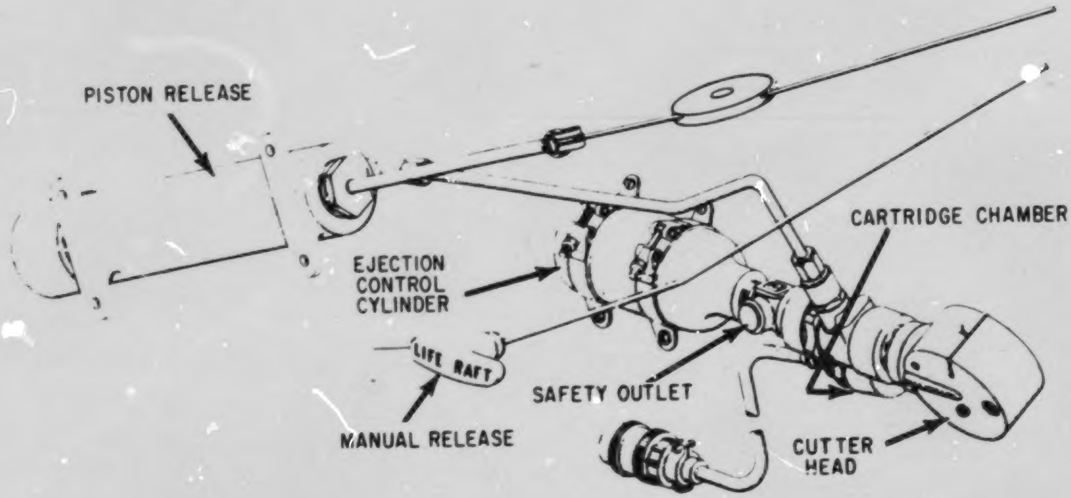
Description of Automatic System

The automatic life raft ejection system is so connected into the manual life raft ejection system that discussion of the automatic feature is not possible without connecting the two. Figure 6-27 shows the principal parts of the emergency actuation system and illustrates their connection with the normal or manual release system.

The automatic life raft release system is incorporated into the emergency escape provisions for use when all available time is needed to escape from the aircraft, and/or to insure deployment of the life raft in case everyone forgot to pull the manual release handle.

When the aircraft is forced to ditch in salt water, some of this water enters a unit known as the submersion actuator and causes the raft to deploy. Water entering the submersion actuator, which is usually located in an out-of-the-way place inside the fuselage, contacts interleaved sets of electrical conductors and completes a circuit. One set of terminals is connected directly to the aircraft battery and the other is connected to ground through the automatic life raft ejection system.

The completed circuit causes a spark which fires a cartridge (fig. 6-27). Expanding gases from the fired cartridge drives a cutter head which ruptures a disc on a small bottle of carbon dioxide. The cartridge, cutter head, and CO_2 bottle are all joined in a common assembly.



AM.116

Figure 6-27.—Life raft control mechanism.

The CO_2 released by the cutter head action is directed through tubing to the retract side of a single-acting actuating cylinder (fig. 6-27), causing it to retract. The rod end of the actuating cylinder is attached to the manual system pull cable or directly to the pull attachment at the life raft door, depending upon the aircraft model. The raft then deploys in the usual manner.

Maintenance

Maintenance of life raft ejections systems includes removal of the raft for inspection purposes, replacement of cylinders that are below the proper weight (indicating correct charge) or that have been discharged, and performing of functional system checkouts as specified in the applicable Maintenance Requirements Cards.

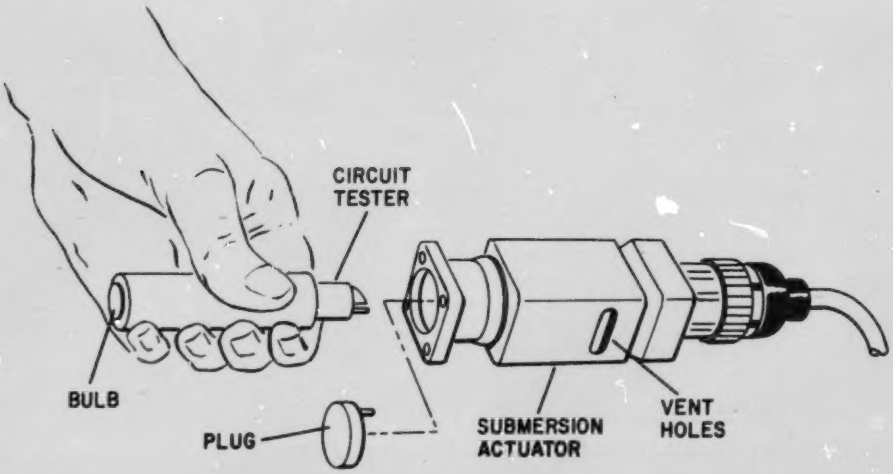
The life raft is removed and reinstalled by the AME, but the inspection must be performed by personnel of the PR rating.

Removal and installation of the life raft varies with each model of aircraft; therefore, detailed step-by-step instructions are included in the applicable Maintenance Instructions Manual. All personnel of the AME rating should be thoroughly familiar with these instructions before attempting to remove or install a life raft in any aircraft.

The submersion actuator is checked periodically by means of a circuit tester which is supplied as part of the test equipment for the particular aircraft. To use the circuit tester, a plastic plug must be removed from the end of the submersion actuator. The circuit tester is inserted in the actuator; and if the actuator is operating properly, the light in the tester will come on. After the completion of the test, insure that the plastic plug is replaced in the actuator. If this plug is accidentally left out, any metallic object small enough to enter the acutator could cause the raft to be ejected in flight. Figure 6-28 illustrates the testing procedure.

The mechanical indicating mechanism on each side of the cutter head (fig. 6-27) is covered with black tape because it is considered unreliable for determining whether the life raft control cylinder needs recharging.

When a control cylinder does not weigh within the proper limits or has been discharged, it must be removed and replaced. Refilling of the cylinder is accomplished at designated AIMD's. The only method of determing the quantity of carbon dioxide (CO_2) in the cylinder is by weighing the cylinder. Because of the small quantity of CO_2 and the cylinder size, an ordinary scale cannot be used. A special scale with an accuracy reading of 1/100 of a pound is necessary.



AM.117

Figure 6-28.—Testing submersion actuator circuit.

Proper charge is stamped on the cylinder with a tolerance of + 0 and -0.05 pounds. In all cases the control cylinder should be charged within these limits and in accordance with the instructions in the applicable Maintenance Instructions Manual.

When installing the cartridge in the cutter head, insure that the correct cartridge is used and that the O-ring and cartridge are installed properly, otherwise the gas pressure created by the firing of the cartridge will escape from the cartridge chamber and insufficient pressure will be created to actuate the cutter.

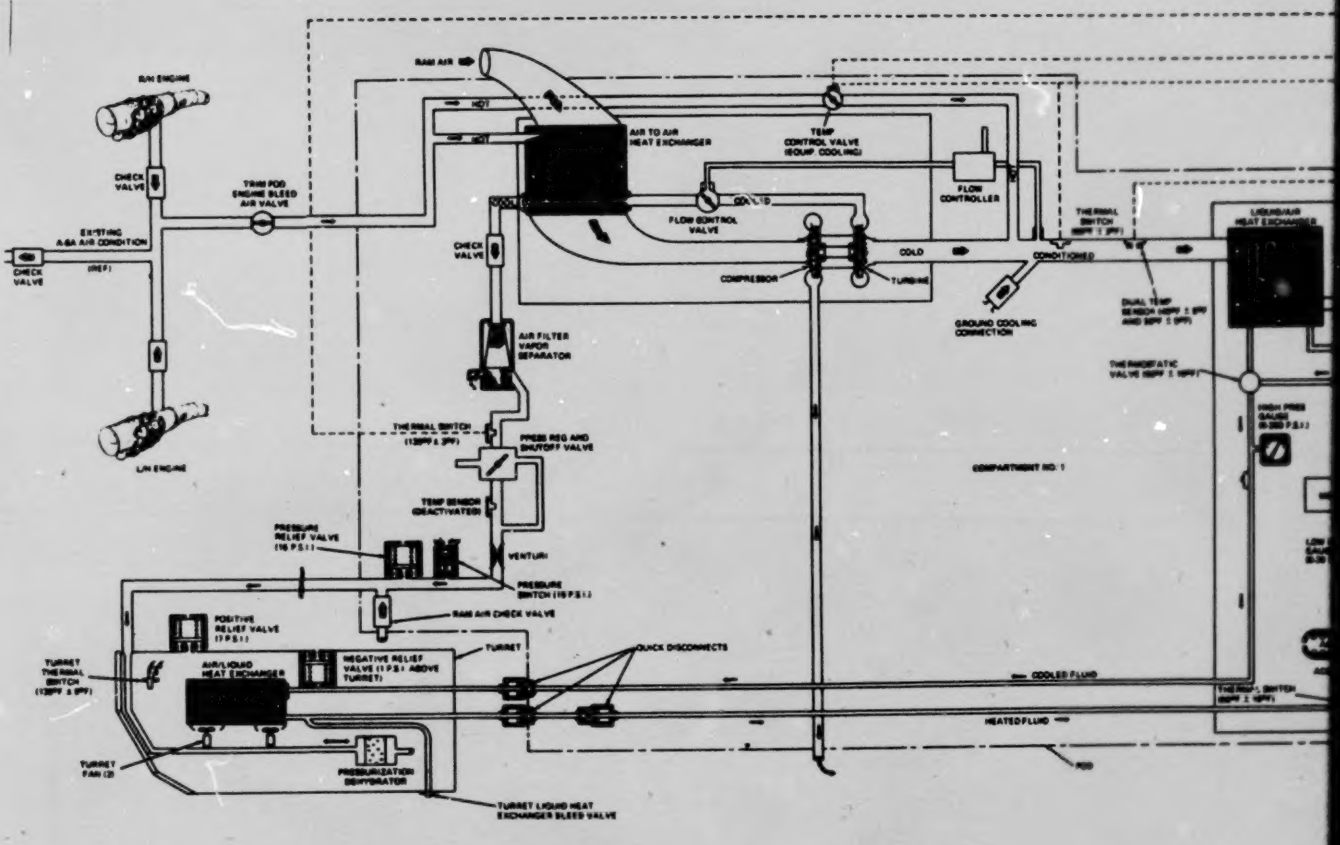
Refilled cylinders are tested for leakage by placing them in cold water for a 12-hour period. Any air bubbles clinging to the cylinder and valve assembly that could be mistaken for leakage are wiped away after the cylinder is submerged in the water. An inverted bottle filled with water is then placed over the cylinder valve assembly to trap any gas leakage over the specific period. Leakage at the valve assembly can generally be corrected or prevented by proper tightening of the valve in the cylinder body.

LIQUID COOLANT SYSTEMS

Mission requirements for some aircraft, such as the RA-5C and the A-6C, necessitate the use of a wide variety of electronic equipment. The operation of such equipment generates heat that shortens the life of the equipment and results in malfunctions. Therefore, the heat must be dissipated in some manner. Chapter 5 provides coverage on the use of the air cycle and vapor cycle air-conditioning systems to maintain electronic equipment compartments within acceptable operating temperatures. The RA-5C and the A-6C utilize liquid coolant systmes to provide additional cooling capacity that cannot be handled by the aircraft's air cycle refrigeration system.

A schematic illustrating the environmental control system used to regulate the environment of the TRIM (Trail Roads Interdiction Multi-Sensor) weapon system equipment located in the turret and aft pod of the A-6C is provided in figure 6-29.

Figure 6-30 provides a pictorial view of the liquid cooling unit. The air-cycle portion of the Trim pod environmental control system functions in much the same manner as the air-cycle system covered in chapter 5. Material in this section therefore covers the pod's air-cycle system only as it affects the liquid coolant system operation.



RAM AIR
R/H ENGINE
CHECK VALVE
TRIM POD ENGINE BLEED AIR VALVE
EXISTING A-6A AIR CONDITION (REF)
CHECK VALVE
L/H ENGINE
HOT
HOT
AIR TO AIR HEAT EXCHANGER
TEMP CONTROL VALVE (EQUIP. COOLING)
FLOW CONTROLLER
FLOW CONTROL VALVE
COOLED
COMPRESSOR
TURBINE
COLD
CONDITIONED
THERMAL SWITCH
GROUND COOLING CONNECTION
DUAL TEMP SENSOR
LIQUID/AIR HEAT EXCHANGER
THERMOSTATIC VALVE
HIGH PRES GAUGE (0-300 P.S.I.)
CHECK VALVE
AIR FILTER VAPOR SEPARATOR
THERMAL SWITCH (120°F ± 3°F)
PRESS REG AND SHUTOFF VALVE
TEMP SENSOR (DEACTIVATED)
PRESSURE RELIEF VALVE (16 P.S.I.)
VENTURI
PRESSURE SWITCH (15 P.S.I.)
RAM AIR CHECK VALVE
POSITIVE RELIEF VALVE (7 P.S.I.)
TURRET
NEGATIVE RELIEF VALVE (1 P.S.I. ABOVE TURRET)
QUICK DISCONNECTS
TURRET THERMAL SWITCH (120°F ± 3°F)
AIR/LIQUID HEAT EXCHANGER
TURRET FAN (2)
PRESSURIZATION DEHYDRATOR
TURRET LIQUID HEAT EXCHANGER BLEED VALVE
COMPARTMENT NO. 1
COOLED FLUID
HEATED FLUID
THERMAL SWITCH
POD

Figure 6-29.—TRIM pod environmental control system.

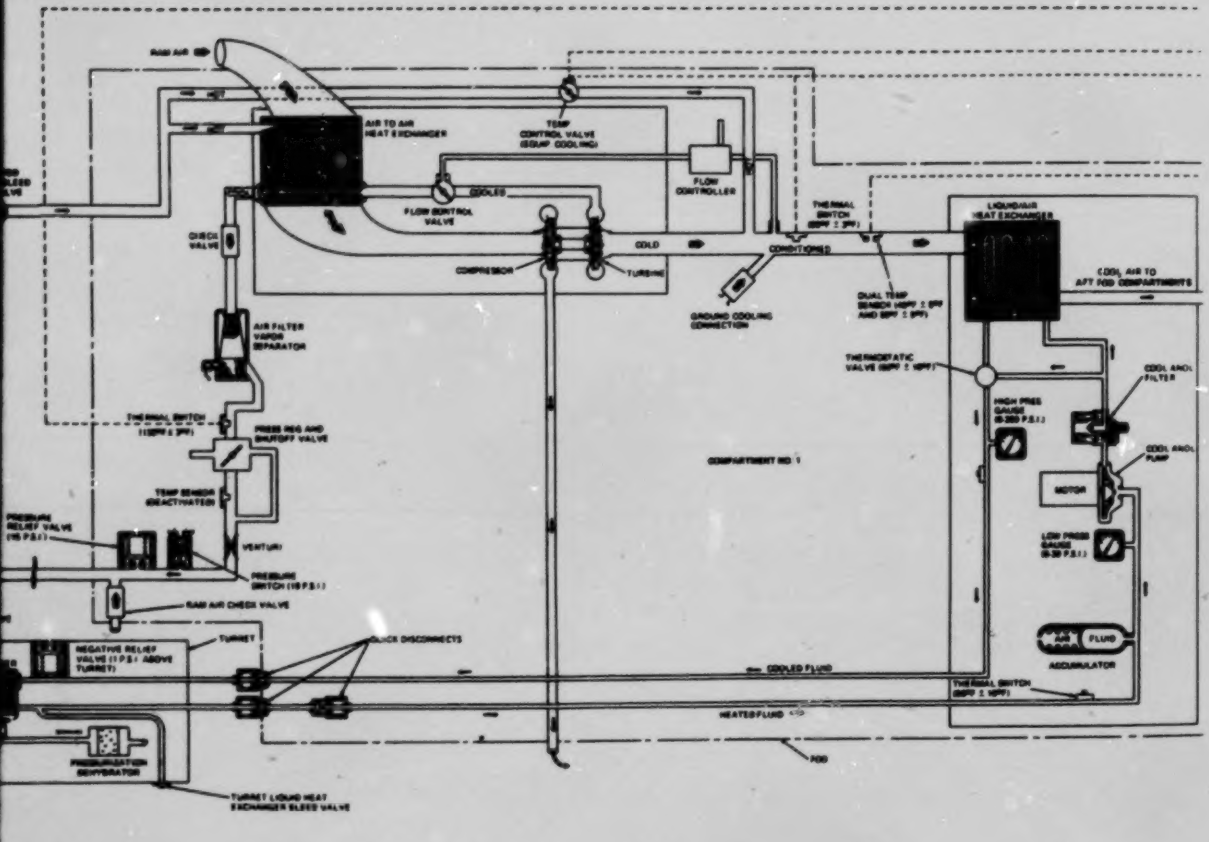

RAM AIR
HOT
AIR TO AIR HEAT EXCHANGER
TEMP CONTROL VALVE (EQUIP COOLING)
FLOW CONTROLLER
COOLED
FLOW CONTROL VALVE
CHECK VALVE
COMPRESSOR
TURBINE
COLD
CONDITIONED
THERMAL SWITCH (60°F ± 3°F)
LIQUID/AIR HEAT EXCHANGER
COOL AIR TO AFT POD COMPARTMENTS
GROUND COOLING CONNECTION
DUAL TEMP SENSOR (40°F ± 3°F AND 60°F ± 3°F)
AIR FILTER VAPOR SEPARATOR
THERMOSTATIC VALVE (60°F ± 10°F)
COOL ANCL FILTER
HIGH PRES GAUGE (0-300 P.S.I.)
THERMAL SWITCH (110°F ± 3°F)
PRESS REG AND SHUTOFF VALVE
COMPARTMENT NO 1
COOL ANCL PUMP
MOTOR
TEMP SENSOR (DEACTIVATED)
PRESSURE RELIEF VALVE (15 P.S.I.)
VENTURI
PRESSURE SWITCH (15 P.S.I.)
LOW PRES GAUGE (0-30 P.S.I.)
RAM AIR CHECK VALVE
TURRET
QUICK DISCONNECTS
NEGATIVE RELIEF VALVE (1 P.S.I. ABOVE TURRET)
AIR
FLUID
ACCUMULATOR
COOLED FLUID
THERMAL SWITCH (60°F ± 10°F)
HEATED FLUID
PRESSURIZATION DEHYDRATOR
POD
TURRET LIQUID HEAT EXCHANGER BLEED VALVE

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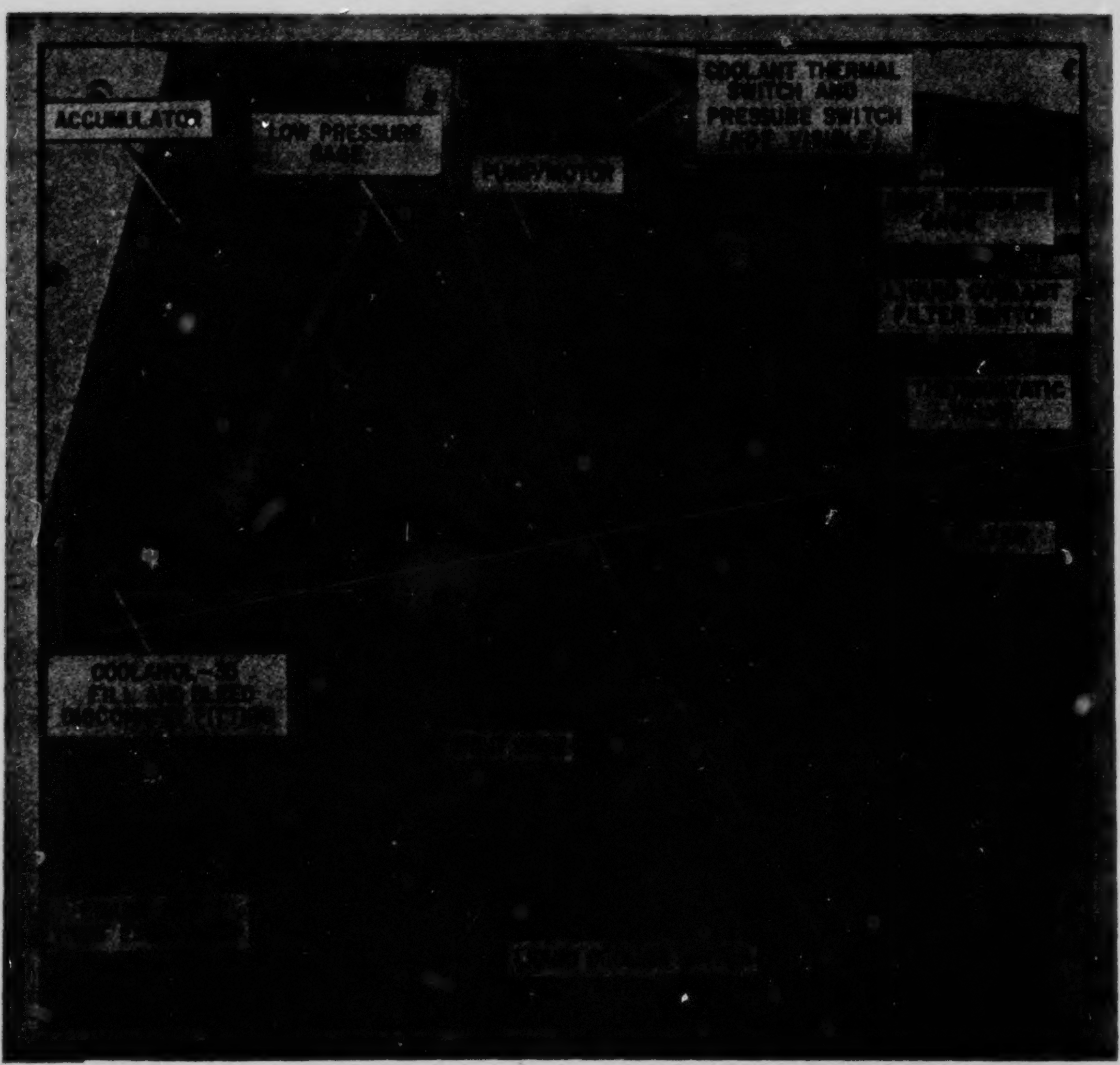
Figure 6-29.—TRIM pod environmental control system.


ACCUMULATOR
LOW PRESSURE GAGE
PUMP/MOTOR
COOLANT THERMAL SWITCH AND PRESSURE SWITCH (NOT VISIBLE)
COOLANOL-35 FILL AND BLEED DISCONNECT FITTING

AM.1161

Figure 6-30.—Liquid cooling unit.

DESCRIPTION/OPERATION

The liquid coolant system section of the pod environmental control system provides cooling for the turret section of the electronic equipment pod. The pod is attached to the lower center fuselage section. The cooling unit uses Coolanol 35 (trade name) coolant liquid as a heat transfer agent. The coolant absorbs heat generated by equipment in the turret section of the pod and transfers this heat to the cold air supplied by the air-cycle turbine as the coolant and air flow through the liquid/air heat exchanger.

The fluid accumulator (fig. 6-29) maintains a positive pressure on fluid going to the suction or inlet port of the coolant pump and provides sufficient liquid volume to compensate for expansion and contraction of the coolant liquid over its full operating temperature range. The coolant is circulated through the filter, the liquid/air heat exchanger, the thermostatic (temperature control) valve, and through the air/liquid heat exchanger in the turret by the electrically driven centrifugal coolant pump.

The bypass type filter has a replaceable 40-micron element and is equipped with a visual clogged indicator pin on the top of the case.

The thermostatic valve senses the temperature of coolant leaving the valve, modulates the flow of coolant through the liquid/air heat exchanger, and operates as a bypass valve to maintain temperature of the coolant in the lines going to the turret section of the system between 40° and 60° F. This results in the temperature of the coolant entering the turret being at approximately 75° F, which is considered the ideal coolant temperature.

The air/liquid heat exchanger is mounted in the top section of the turret. Air is circulated throughout the turret and through the cores of the exchanger by the two electric-motor-driven fans mounted on the heat exchanger. The circulating air absorbs heat generated by the electronic equipment and transfers this heat to the coolant as it passes through the air/liquid heat exchanger cores.

The turret section liquid coolant components are connected to the cooling unit (fig. 6-30) by hoses equipped with quick-disconnect fittings. The cooling unit is located in the pod adjacent to the turret.

The low- and high-pressure gages on the cooling unit (fig. 6-30) indicate coolant suction pressure at the pump inlet and system high side pressure. Both readings are dependent on coolant temperature with a fixed coolant charge in the system.

MAINTENANCE

Organizational level maintenance of the liquid coolant system consists of servicing the system with Coolanol 35, periodic inspection, operational testing, and troubleshooting.

The operating, testing, and troubleshooting procedures provided in the Maintenance Instructions Manual are presented in chart form and consist of a series of go no-go checks that include the use of test equipment and various cockpit control settings. The operational check is performed by personnel of the AE and AME ratings.

Figure 6-31 illustrates a page of the operational testing and troubleshooting procedures sheet utilized with the TRIM pod environmental control system. The chart points out that an AN/PSM-4 multimeter is necessary to check electrical components. Note the various references to liquid coolant system components and trace the various no-go and go procedures in proper sequence.

An environmental control test set, available and normally used by personnel of the AE rating, provides efficient system trouble analysis. The test set performs three types of checks. It can check the resistance of various system temperature sensors. An abnormal resistance reading would indicate a faulty sensor. It can substitute the fixed values of resistance of the aircraft's temperature sensors and thus check for proper operation of the system temperature controller as well as voltage outputs which cause the system valves to change position. Thirdly, it can measure voltages at various points throughout the system from a single point connection.

A fault symptom index is also provided in the MIM for the use of maintenance personnel in locating the cause of faults/malfunctions. The index illustrated in figure 6-32 is layed out in the format common to avionics weapon system debriefing guides. They contain a complete lists of all the environmental control system faults that could normally be expected during a flight, or during postflight or post-maintenance operational checks. Questions asked in the second column of the index can be answered yes or no and will lead the user to the course of action as stated in the maintenance action columns.

If the fault involves other subsystems, some of the maintenance actions or instructions required to eliminate or correct the fault may be covered in another Maintenance Instructions Manual. If this is the case, the index will refer the user to troubleshooting and operational checkout procedures in the appropriate MIM. Faults of this nature are listed in the environmental control system fault index only because they might appear as environmental control system malfunctions or faults.

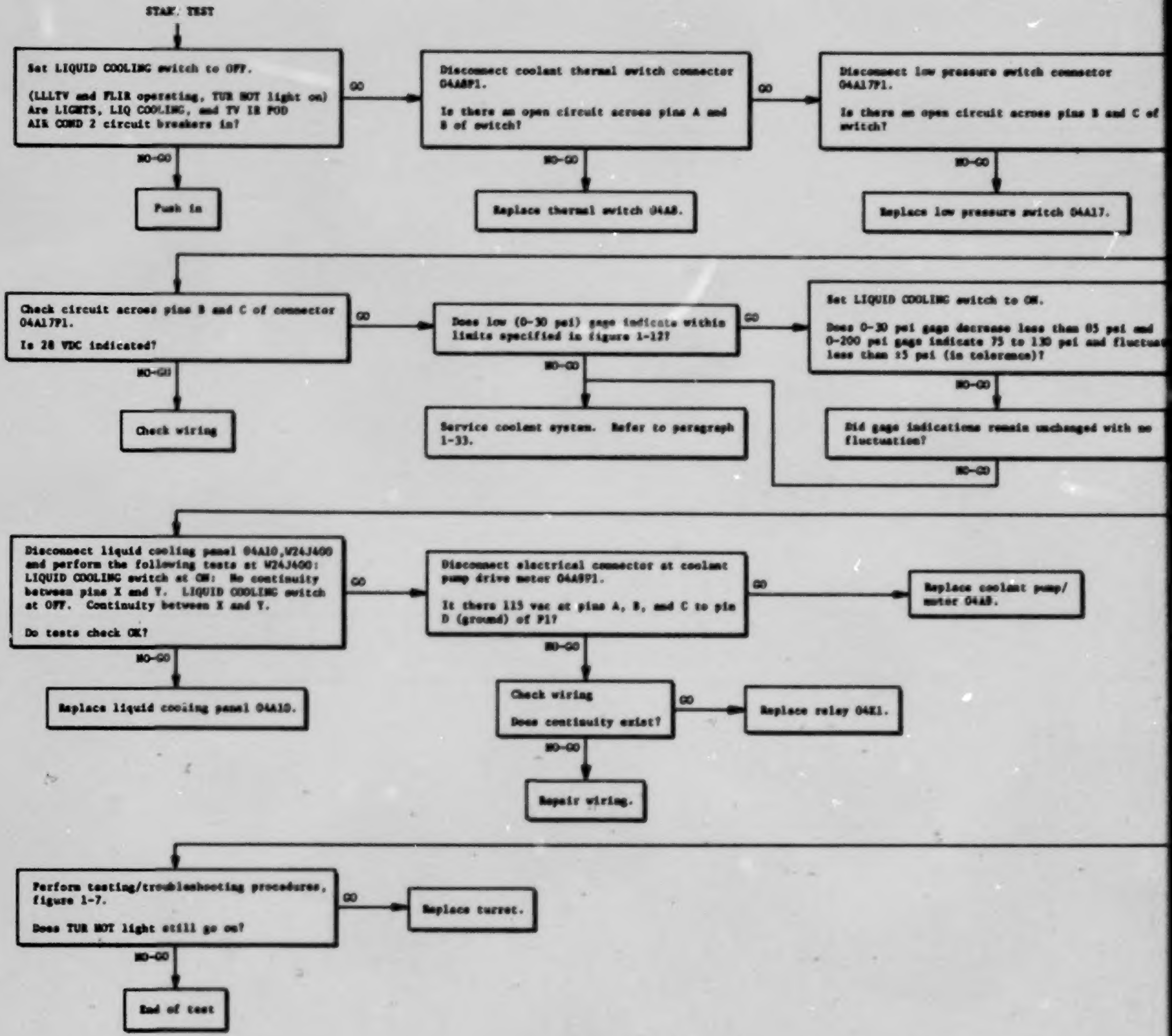
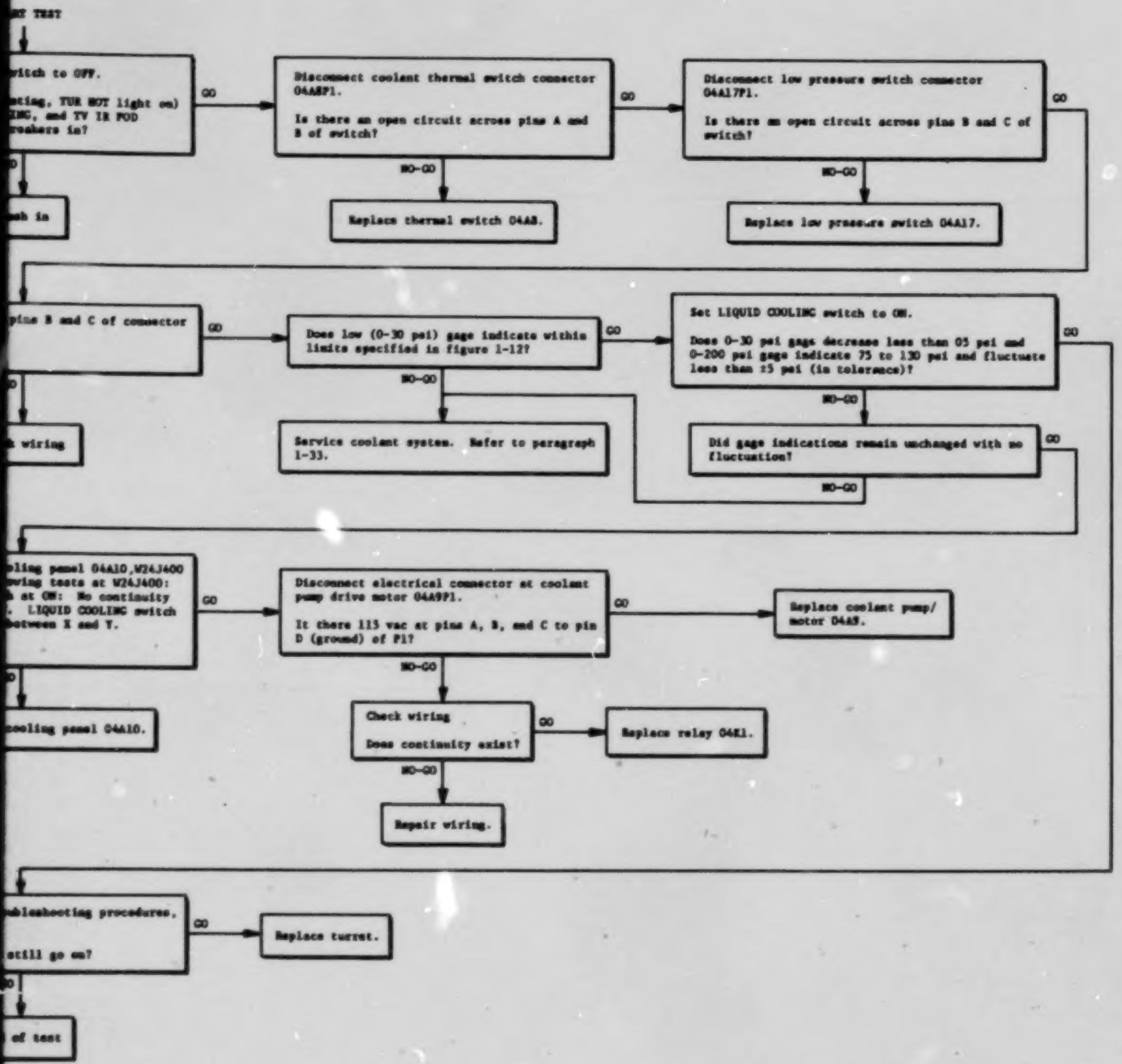

START TEST
Set LIQUID COOLING switch to OFF.
(LLLTV and FLIR operating, TUR HOT light on) Are LIGHTS, LIQ COOLING, and TV IR POD AIR COND 2 circuit breakers in?
GO
NO-GO
Push in
Disconnect coolant thermal switch connector 04A8P1.
Is there an open circuit across pins A and B of switch?
GO
NO-GO
Replace thermal switch 04A8.
Disconnect low pressure switch connector 04A17P1.
Is there an open circuit across pins B and C of switch?
NO-GO
Replace low pressure switch 04A17.
Check circuit across pins B and C of connector 04A17P1.
Is 28 VDC indicated?
GO
NO-GO
Check wiring
Does low (0-30 psi) gage indicate within limits specified in figure 1-12?
GO
NO-GO
Service coolant system. Refer to paragraph 1-33.
Set LIQUID COOLING switch to ON.
Does 0-30 psi gage decrease less than 05 psi and 0-200 psi gage indicate 75 to 130 psi and fluctuat
less than ±5 psi (in tolerance)?
NO-GO
Did gage indications remain unchanged with no fluctuation?
NO-GO
Disconnect liquid cooling panel 04A10,W24J400 and perform the following tests at W24J400: LIQUID COOLING switch at ON: No continuity between pins X and Y. LIQUID COOLING switch at OFF. Continuity between X and Y.
Do tests check OK?
GO
NO-GO
Replace liquid cooling panel 04A10.
Disconnect electrical connector at coolant pump drive motor 04A9P1.
It there 115 vac at pins A, B, and C to pin D (ground) of P1?
GO
NO-GO
Replace coolant pump/motor 04A9.
Check wiring
Does continuity exist?
GO
NO-GO
Replace relay 04K1.
Repair wiring.
Perform testing/troubleshooting procedures, figure 1-7.
Does TUR HOT light still go on?
GO
NO-GO
Replace turret.
End of test

Figure 6-31.—Operating, testing, and troubleshooting procedures chart.



…T TEST
…witch to OFF.
…ting, TUR HOT light on)
…ING, and TV IR POD
…reakers in?
GO
…O
…sh in
Disconnect coolant thermal switch connector 04A8P1.
Is there an open circuit across pins A and B of switch?
GO
NO-GO
Replace thermal switch 04A8.
Disconnect low pressure switch connector 04A17P1.
Is there an open circuit across pins B and C of switch?
GO
NO-GO
Replace low pressure switch 04A17.
…pins B and C of connector
GO
…O
…k wiring
Does low (0-30 psi) gage indicate within limits specified in figure 1-12?
GO
NO-GO
Service coolant system. Refer to paragraph 1-33.
Set LIQUID COOLING switch to ON.
Does 0-30 psi gage decrease less than 05 psi and 0-200 psi gage indicate 75 to 130 psi and fluctuate less than ±5 psi (in tolerance)?
GO
NO-GO
Did gage indications remain unchanged with no fluctuation?
GO
NO-GO
…oling panel 04A10,W24J400
…wing tests at W24J400:
…h at ON: No continuity
…. LIQUID COOLING switch
…between X and Y.
GO
…O
…cooling panel 04A10.
Disconnect electrical connector at coolant pump drive motor 04A9P1.
It there 115 vac at pins A, B, and C to pin D (ground) of P1?
GO
Replace coolant pump/motor 04A9.
NO-GO
Check wiring
Does continuity exist?
GO
Replace relay 04K1.
NO-GO
Repair wiring.
…ubleshooting procedures,
…still go on?
GO
Replace turret.
…O
… of test

AM.1162

Figure 6-31.—Operating, testing, and troubleshooting procedures chart.

FAULT	QUESTION	MAINTENANCE ACTION			
		YES		NO	
		FIGURE	PARAGRAPH	FIGURE	PARAGRAPH
1. INFLIGHT PROBLEMS a. TUR HOT light on, POD CLG light out.	1a1. Was FLIR or LLL TV malfunctioning prior to TUR HOT lighting?	Refer to NAVAIR 01-85ADD-2-2-.1	—	Go to 1a2.	—
	1a2. Did TUR HOT light go on, then FLIR and LLL TV suddenly shut off?	Go to 1a3.	—	Go to 1a4.	—
	1a3. Did TUR HOT light go on in post flight check (POD CLG light still out) and FLIR and/or LLL TV were not operating?	1-7	1-33	Go to 1a4.	—
	1a4. Did TUR HOT light go on only when FLIR and/or LLL TV systems were operating in post flight check?	1-8	1-33	Go to 1b.	—
b. POD CLG light on, TUR HOT light out.	1b1. (None.)	1-9	1-34	Go to 1c.	—
c. LLL TV and/or FLIR display out of focus or shows wavy (heat) lines	1c1. Was TV/IR cooling switch held at RESET for 6 seconds, then set to Norm; and display problems continued?	1-10	1-32	Go to 2a.	—
2. PREFLIGHT AND POSTFLIGHT PROBLEMS ⚠1					
a. FULL COLD light on.	2a1. (None.)	1-10	1-32	Go to 2b.	—
b. No exhaust from window exhaust port on pod.	2b1. Was TV/IR COOLING switch in cockpit at NORM?	Go to 2b2.	—	Reset switch.	—
	2b2. Was POD CLG light on?	1-9	1-34	Go to 2c1.	—
c. Air filter vapor separator red button up.	2c1. (None.)	Replace	1-85	—	—
d. Bubbles or contaminants in sight gage.	2d1. (None.)	Service	1-36	—	—
e. Liquid coolant red filter button up.	2e1. (None.)	Replace	1-36	—	—
f. Coolant low (0-30 psi) and/or high (0-200 psi) pressure gages out of tolerance.	2f1. On static test, did low (0-30 psi) gage indicate 5 to 10 psi and high (0-200 psi) gage indicate 75 to 130 psi (dependant on temperature)?	Service	1-36	—	—
	2f2. When coolant system was operating, did low (0-30 psi) gage indication decrease more than 0.5 psi or high (0-200 psi) gage fluctuate more than ±5 psi?	Service	1-36	—	—
⚠1 2g. Windows cracked or broken.	2g1. Were exterior windows broken outward and/or interor windows broken inward?	1-10	1-32	—	—
	2g2. Was window exhaust port clogged?	1-10	1-32	—	—

⚠1 On aircraft not incorporating AFC 261

AM. 1163

Figure 6-32.—Fault symptom index–A-6C TRIM pod environmental control system.

Servicing

Servicing instructions for the liquid coolant system are provided in the applicable MIM and the "Postflight, Servicing, and Conditional" Maintenance Requirements Card deck. The use of the fill and bleed cart illustrated in figure 6-33 is required to drain, degas, replenish, and pressurize the liquid coolant system.

The numbers in table 6-1 identify the callouts in figure 6-33 and describe the function of the various controls and indicators found on the cart. The cart is capable of circulating the liquid coolant at approximately 2 gallons per minute at 12 psi. The liquid coolant attempts to gasify and circulating the liquid reduces the content of dissolved gases to 5 percent or less by volume.

The cart vacuum pump maintains a vacuum on the cart reservoir of 27 in. Hg, and the positive displacement fluid pump circulates the fluid during the degasssing of the coolant as a step in servicing the system.

The cart reservoir is surrounded by a heating blanket which is utilized to raise the fluid temperature. Raising the fluid temperature aids in the removal of air and moisture from the coolant liquid.

The pressure and return hoses of the cart are 18 feet long and are equipped with quick-disconnect fittings. The cart pressure regulator valve is preset to regulate the coolant outlet pressure from 9 to 15 psi.

The cart reservoir fluid level should always be maintained between the LOW LEVEL and FULL STAND ONLY markings on the reservoir level sight tube. (See fig. 6-33, detail A.)

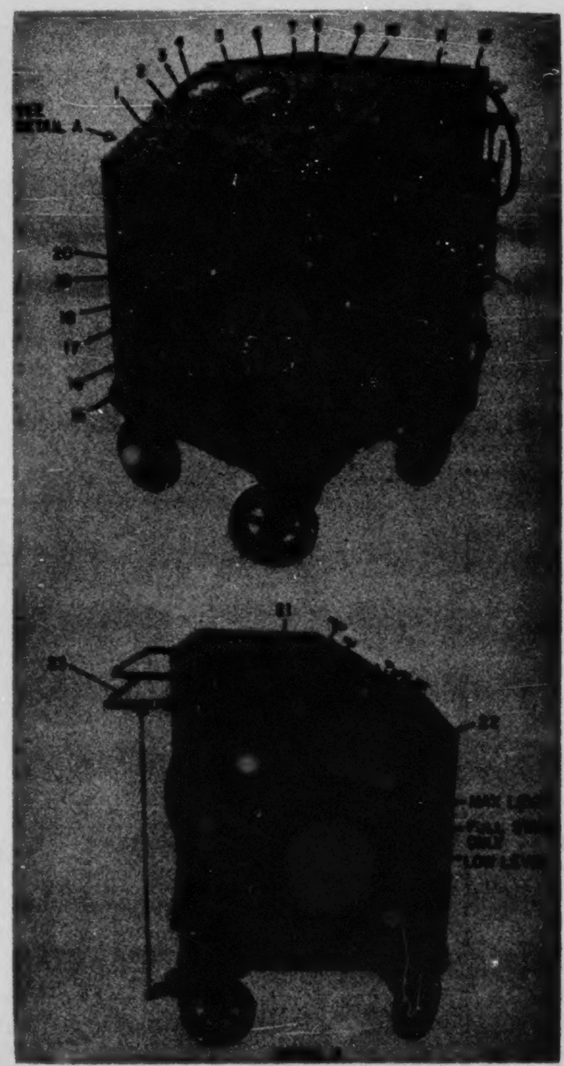
With the cart properly serviced and degassed in accordance with the procedures outlined in the MIM and the TRIM pod liquid coolant switch in the OFF position, servicing of the coolant system is accomplished in the following manner:

1. Close the return shutoff (10) and pressure outlet shutoff (13) valves of the servicing cart and connect the pressure and return lines to the cooling system servicing quick disconnects (fig. 6-30).

2. Connect the fill and bleed cart to an appropriate electrical power supply.

3. Position the bypass valve (14) open one full turn and the reservoir vent (2), reservoir pressure gage (5), and outlet pressure gage (3) valves to full open.

4. Press the pump start button (18) and operate the pump for 3 to 4 minutes. Monitor the outlet pressure gage (4) for a pressure indication between 9 to 15 psi with a reservoir temperature gage (1) indication between 80° to 190° F.



AM. 1164

Figure 6-33.—Liquid coolant system fill and bleed cart.

NOTE: If the reservoir temperature indicates below 80° F, utilize the reservoir heater to raise the temperature between 80° to 90° F, then turn the heater OFF. If reservoir temperature is over

Table 6-1.—Fill and bleed cart controls and indicators.

Number	Control or Indicator	Function
1	RESERVOIR TEMP.	Indicates reservoir fluid temperature in degrees F for effective degassing operation.
2	RESERVOIR VENT VALVE.	When closed, enables buildup of vacuum in cart. Opened to allow entrance of air to equalize pressure.
3	OUTLET PRESS. GAGE valve.	Isolates OUTLET PRESS. GAGE from cart system for test and calibration.
4	OUTLET PRESS. GAGE	Indicates cart pump pressure.
5	RESERVOIR PRESS. GAGE valve.	Isolates RESERVOIR PRESS. GAGE from cart system for test and calibration.
6	RESERVOIR PRESS. GAGE.	Indicates reservoir pressure/vacuum.
7	ELAPSED TIME Indicator.	Indicates cart operating hours.
8	PRESS. REGULATOR.	Controls cart pump pressure to maintain pressure output to aircraft.
9	SIGHT TUBE.	Displays return flow of fluid from aircraft to cart or indicates flow of fluid during cart degassing operation.
10	RET. SHUTOFF.	Controls return flow of fluid from aircraft to cart. Assists in pressurizing aircraft.
11	PRESS. OUTLET Hose.	Connects cart pressure outlet to aircraft quick-disconnect fill and bleed connection.
12	RETURN OUTLET Hose.	Connects cart return lines to aircraft quick-disconnect fill and bleed connection.
13	PRESS. OUTLET SHUTOFF.	Controls pressurized fluid flow to aircraft.
14	BYPASS VALVE.	Controls flow for cart fluid circulation.
15	VACUUM PUMP Indicator Light	Mounted adjacent to VACUUM PUMP switch and lights when VACUUM PUMP is operating.
16	VACUUM PUMP Switch.	START-STOP buttons operate vacuum system.
17	PUMP Indicator Light.	Mounted adjacent to PUMP switch and lights when pump is operating.
18	PUMP Switch.	START-STOP buttons operate liquid pump to circulate and transfer liquid to aircraft or through cart. STOP button also turns off heater through an interlock.
19	HEATER Indicator Light.	Mounted adjacent to HEATER switch and lights when heater is operating.
20	HEATER Switch.	Operates when PUMP switch is on. Heats reservoir liquid to aid in removal of gasses and moisture.

Table 6-1.—Fill and bleed cart controls and indicators. (Cont'd)

Number	Control or Indicator	Function
21	Power Cable.	Connects cart to 115-volt a. c. 60 Hz power supply.
22	Reservoir Level Sight Tube.	Indicates liquid level in cart reservoir.
23	Dead Man Brake.	Locks brakes of rigid casters when handle is released.

190° F, secure the cart until the temperature drops to 135° F before resuming the servicing operation.

5. Start the vacuum pump and slowly close the reservoir vent valve (2) until the reservoir pressure gage (6) indicates an increase of 1 in. Hg. Hold this setting 1 minute, then repeat this step until the reservoir vent valve is fully closed.

NOTE: At this point the outlet pressure gage should read between 4 to 10 psi and the reservoir temperature should be between 80° to 190° F.

6. Fully open the pressure outlet shutoff valve (13) and open the return shutoff valve (10) one full turn.

7. Slowly close the bypass valve (14) and observe that the outlet pressure is maintained at 4 to 10 psi.

8. Allow the cart to circulate coolant through the cart and the aircraft system for 20 to 40 minutes, then secure the vacuum pump. An elapsed-time meter is provided on the cart.

9. Close the return shutoff valve until an outlet pressure gage reading of 9 to 15 psi is maintained.

10. Close the pressure outlet shutoff valve, stop the cart pump, and open the reservoir vent valve to reduce the reservoir pressure to zero.

11. Observe the cart reservoir temperature gage and refer to the liquid coolant temperature versus pressure chart in the MIM to determine the proper charging pressure.

12. Observe the aircraft's liquid cooling system low-pressure gage (fig. 6-30) and bleed the aircraft's system down to the pressure determined in step 11 by slightly opening the return shutoff valve on the cart.

13. Disconnect and secure the servicing cart and reconnect the aircraft quick-disconnect servicing fittings.

14. Following servicing, perform a functional check of the coolant system in accordance with the instructions provided in the applicable Maintenance Instructions Manual.

THERMAL RADIATION PROTECTION SYSTEMS

Naval aircraft utilized for special weapons delivery have some means of protecting the pilot and crewmembers from the effects of heat and light that such weapons emit. Several of the Navy attack type aircraft are equipped with thermal radiation protection system and flak protection curtains.

The A-6, for example, can be equipped with radiation enclosures for the windshield and canopy. These enclosures shield off the see-through portions of the cockpit and thus afford the flight crew protection from the extreme heat and light created by a special weapons delivery.

AM.1165

Figure 6-34.—Canopy radiation shields.

The radiation shields illustrated in figure 6-34 consist of fixed and sliding fiberglas panels that are mounted on each side of the canopy. The sliding panels are equipped with rollers and suspended on a system of tracks between the fixed side panels and the canopy center overhead spline structure.

The sliding panels for each side of the canopy move independently of each other and are manually positioned by the pilot or bombardier/navigator. The shield is closed by pulling the forward sliding panel towards the canopy forward arch. The forward panel is equipped with a lip which engages on the lip of the aft sliding panel, drawing it forward at the same time.

The slide panels will automatically lock in one of three positions; open, closed, or half open, as desired. A latch handle on each forward sliding panel releases the detent pins, unlocking the panels.

If the panels are closed and ejection becomes necessary, it may be initiated through the closed shields.

The windshield curtain is a fiberglas cloth assembly with an aluminized coating. It is fastened between the instrument panel glare shield and the windshield bow structure to close off the entire windshield area. Springs pull the windshield curtain down flat on the glare shield for stowage when the curtain is unzipped.

Flak curtains, similar to the canopy curtain, shown in figure 6-35, are mounted beside the pilot and bombardier/navigator foot area, cockpit side area, and along the lower portion of the canopy. They provide a limited measure of protection from flak and small arms fire when making low level attacks on enemy positions.

AM. 1166
Figure 6-35.—Canopy side panel flak curtain.

The canopy mounted curtain is a sandwich type pad constructed on vinyl coated glass cloth with a nylon center. The cockpit area side panels are basically the same construction with the outboard vinyl coating deleted. The foot guard panel is constructed of a metal plate with a nylon curtain riveted to the outboard side. Installation of the flak curtains prior to takeoff will depend upon mission requirements.

The radiation protection system on the A-7 aircraft is similar to that of the A-6 except that it may be opened or closed manually or closed automatically using pneumatic system pressure.

The A 7 protective closure consists of one fixed and three movable fiberglas segments which enclose the entire cockpit viewing area when extended. The forward segment of the closure presses against the instrument panel cowl so that a windshield curtain is not necessary.

In the open position, the movable segments are retracted within the contour of the fixed segment so that they do not restrict the pilot's vision.

An overcenter spring on each side of the closure holds the panels in either the open or closed positions.

The automatic closing sequence is accomplished in 0.2 second. A lock on the left-hand canopy frame locks the closure open and prevents extension until it is manually released.

Interference tolerances between the ejection seat and the closure panels require that the seat be within 1/4-inch of the full down position prior to closure operation.

Manual actuation of the system is initiated by placing the thermal closure switch to the CLOSE position. This will cause the ejection seat to be automatically lowered to provide proper clearance. As the seat lowers, it actuates a seat position switch which directs current to the closure selector valve. The energized valve releases 1,000 psi pneumatic system pressure through a restrictor to the two closure actuators, rapidly extending the closure panels.

When the thermal closure switch is released, it returns to the OFF position, deenergizing the closure selector valve and blocking pneumatic system pressure to the actuator extend lines. Deenergizing of the selector valve also vents the extend lines so that the closure panels may be manually opened or closed as necessary.

In the automatic mode of operation, the thermal closure system operates in the same manner except the solenoid of the closure selector valve is grounded through a switching demodulator unit rather than the thermal closure switch. The switching unit energizes the closure selector valve and turns ON the white cockpit floodlights when the system is initiated (triggered) by a nuclear flash sensor.

The nuclear flash sensor is mounted on the pilot's flight helmet. When activated by high intensity light, such as that created by a nuclear blast, the sensor energizes the closure selector valve for approximately 3 seconds. The closures extend, are held closed for the 3-second interval, and then the valve is deenergized and the actuator lines are vented to allow manual opening and closing of the panels.

NOTE: When flying a special weapons mission in the A-7, the pilot's helmet is equipped with a flash-blindness protective (ELF) lens. When the nuclear flash sensor that closes the radiation panels is activated, current is also directed to detonate a very small explosive charge contained in the lens. The exploding charge releases a light-blocking graphite suspension to the inner core of the lens to protect the pilot's eyes from ther thermal flash while the closure panels are extending. The ELF lens are normally stored in containers in the cockpit when not in use.

CHAPTER 7

GASEOUS OXYGEN SYSTEMS

IMPORTANCE OF OXYGEN

No one can live unless he is able to get sufficient quantities of food, water, and oxygen. Of the three, oxygen is by far the most urgently needed. If necessary, a well-nourished man can go without food for many days or weeks, living on what is stored in his body. The need for water is more immediate but still will not become critical for several days. The stock of oxygen in the body is limited at best to a few minute's supply. When that supply is exhausted, death is prompt and inevitable.

Oxygen starvation affects a pilot or aircrewman in much the same way that it affects an aircraft engine. Both the man and the engine require oxygen for the burning of fuel. An engine designed for low-altitude operation loses power and performs poorly at high altitudes. High-altitude operation demands a means of supplying air at higher pressure to give the engine enough oxygen for the combustion of its fuel. The supercharger or compressor performs this function.

The combustion of fuel in the human body is the source of energy for everything the aviator is required to do with his muscles and with his eyes and brain. As the aircraft climbs, the amount of oxygen per unit of volume of air decreases and the aviator's oxygen intake, therefore, is reduced. Unless he breathes additional oxygen, his eyes, his brain, and his muscles begin to fail him. He is designed for low-altitude operation and will not give satisfactory performance unless he is supplied the full amount of oxygen that his body requires. Like the engine, the body requires a means of having this oxygen supplied to it in greater amounts or under greater pressure. This need is satisfied by use of supplemental oxygen supplied directly to the respiratory system through an oxygen mask, by pressurizing the aircraft (chapter 5) to a pressure equivalent to that at safe-breathing altitudes, or both.

For purposes of illustration, an aviator's lungs may be compared with a bottle of air since the air in the lungs behaves in the same way. If an open bottle is placed in an aircraft at sea level, air will escape from it continuously as the aircraft ascends. As was learned in chapter 5, the air pressure at 18,000 feet is only half that at sea level; therefore, at 18,000 feet the bottle will be subjected to only half the atmospheric pressure it was subjected to at sea level. For this reason, it will contain only half the oxygen molecules it had when on the ground.

In like fashion, an aviator's lungs contain less and less air as he ascends and correspondingly less oxygen. Thus, the use of supplemental oxygen is an absolute necessity on high-altitude flights.

Up to about 35,000 feet an aviator can keep a sufficient concentration of oxygen in his lungs to permit normal activity by use of oxygen equipment that supplies oxygen upon demand (inhalation). The oxygen received by the body on each inhalation is diluted with decreasing amounts of air up to about 33,000 feet. Above this altitude up to about 35,000 feet, this equipment provides 100 percent oxygen. At about 35,000 feet, inhalation alone will not provide enough oxygen with this equipment. This is DEMAND oxygen equipment.

Above 35,000 feet, normal activity is possible up to about 43,000 feet by use of PRESSURE DEMAND equipment. This equipment consists of a "supercharger" arrangement by which the oxygen is supplied to the mask under a pressure slightly higher than that of the surrounding atmosphere. Upon inhalation (demand) the oxygen is forced (pressure) into the mask by the system. Upon exhalation the oxygen pressure is shut off automatically so that carbon dioxide can be expelled from the mask. Above 43,000 feet, the only adequate provision for the safety of the aviator is pressurization of the entire body, as described in chapter 5.

EFFECTS OF LACK OF OXYGEN

HYPOXIA

A decrease in the amount of oxygen per unit volume of air results in an insufficient amount of oxygen entering the bloodstream. The body reacts to this condition rapidly. This deficit in oxygen is called HYPOXIA. A complete lack of oxygen, which causes death, is called ANOXIA. If the body is returned to its normal oxygen supply, one may recover from hypoxia, but cannot recover from anoxia.

Many persons are not aware of the enormous increase in need for oxygen caused by an increase in physical activity. Strenuous calisthenics or a cross-country run results in deep and rapid breathing. Even so mild an exercise as getting up and walking around a room may double the air intake. In the case of the aviator, leaking of an oxygen mask which may go completely unnoticed while the wearer is at rest may lead to collapse and unconsciousness when he attempts to move about from one station to another in the aircraft. A walkaround (portable) oxygen bottle sufficient for 24 minutes of quiet breathing may be emptied by 17 minutes of use when the user is moving about the aircraft.

Effects of Hypoxia

Men differ in their reactions to hunger, thirst, and other sensations. Even an individual's reactions vary from time to time under different circumstances. Illness, pain, fear, excessive heat or cold, and many other factors govern what the response will be in each particular case. The same thing is true of individual reactions to oxygen starvation. The effects of a certain degree of hypoxia on a given person cannot be accurately predicted. For instance, a person may be relatively resistant on one day, but highly susceptible the next.

It is difficult to detect hypoxia, because its victim is seldom able to judge how seriously he is affected, or often that he is affected at all. The unpleasant sensations experienced in suffocation are absent in the case of hypoxia. Blurring of vision, slight shortness of breath, a vague, weak feeling, and a little dizziness are the only warnings. Even these may be absent or so slight as to be unnoticeable.

While still conscious, the aviator may lose all sense of time and spend his last moments of consciousness in some apparently meaningless activity. In such a condition he is a menace to his crew as well as to himself. Since the aviator understands that it is the reduced air pressure at higher altitudes which determines the effect upon his body, he depends upon the altimeter rather than his sensations or judgment to tell him when he needs oxygen. The effects of hypoxia at various altitudes are discussed in the following paragraphs:

BELOW 10 THOUSAND FEET.—Even below 10,000 feet some effects of hypoxia are present. Generally, the eye is the first part of the body to suffer effects of hypoxia. At a relatively low altitude of 5 to 6 thousand feet, where no other effects of hypoxia can be detected, night vision is appreciably reduced. At 10,000 feet, night operations may be seriously handicapped by poor night vision which is due to mild oxygen starvation. Thus, the use of supplemental oxygen on night flights above 5,000 feet is required. Although hypoxia affects the eyes in the daytime as well as at night, the results during the day are usually not as readily noticed below 10,000 feet.

BETWEEN 10 AND 15 THOUSAND FEET.—Although efficiency may be considerably impaired at 10 or 15 thousand feet, death from oxygen starvation at these altitudes is virtually unknown. The greatest dangers are from errors in judgment or performance due to drowsiness or mental confusion. At these altitudes, long flights without oxygen often produce persistent drowsiness and even excessive fatigue for many hours afterward. Frequently, persistent headaches develop soon after completion of the flight. For these reasons, the use of oxygen on flights above 10,000 feet is required. Convenient portable oxygen systems are available for aircraft which do not normally carry oxygen equipment.

BETWEEN 15 AND 20 THOUSAND FEET.—Flights at 15 to 20 thousand feet, even for short periods, must not be attempted without the use of oxygen. Collapse and unconsciousness are not uncommon. Failure to use oxygen may even result in death, especially when the situation is complicated by loss of blood in combat or by shock due to pain or fear.

BETWEEN 20 AND 25 THOUSAND FEET.—During World War II, a great proportion of military flying was done in nonpressurized aircraft between 20 and 25 thousand feet. Most of the deaths from anoxia occurred in this altitude range. The symptoms of drowsiness, mental confusion, dim vision, and dizziness prevail here as at lower altitudes, but they come much more quickly, giving less opportunity for corrective action. Consequently, under no circumstances should aircraft ascend to these altitudes, even for short periods, without the use of oxygen by all persons aboard. The movement of personnel in the aircraft requires the constant use of walkaround equipment. Unusual actions or failure of a crewmember to respond quickly and clearly, when called, requires immediate investigation.

BETWEEN 25 AND 30 THOUSAND FEET.—Between 25 and 30 thousand feet, collapse, unconsciousness, and death follow interruption of the oxygen supply within a very short time. Mask leakage at these altitudes may cause a degree of hypoxia which, although not noticed during flight, can produce considerable fatigue and have serious cumulative effects.

ABOVE 30 THOUSAND FEET.—Above 30,000 feet, unconsciousness and death strike rapidly and often without warning. At such altitudes, it is imperative that all oxygen equipment be functioning correctly and that each breath be taken through a properly fitted oxygen mask. Above a pressure altitude of 35,000 feet, pressure breathing oxygen equipment is required.

CHARACTERISTICS OF OXYGEN

Oxygen, in its natural state, is a colorless, odorless, and tasteless gas. Oxygen is considered to be the most important to life of all the elements. It forms about 21 percent of the atmosphere by volume and 23 percent by weight.

Of all the elements in the universe, oxygen is the most plentiful. It makes up nearly one-half of the earth's crust and approximately one-fifth of the air we breathe.

Oxygen combines with most of the other elements. The combining of an element with oxygen is called oxidation. Combustion is simply rapid oxidation. In almost all oxidations, heat is given off. In combustion the heat is given off so rapidly it does not have time to be carried away; the temperature rises extremely high, and a flame appears.

Some examples of slow oxidation are the rusting of iron, drying of paints, and the changing of alcohol into vinegar. Even fuels in storage are slowly oxidized, the heat usually being carried away fast enough; however, when the heat cannot easily escape, the temperature may rise dangerously and a fire will break out. This is called spontaneous combustion.

Oxygen does not burn, but does support combustion. Nitrogen neither burns nor supports combustion. Therefore, combustible materials burn more readily and more vigorouly in oxygen than in air, since air is composed of about 78 percent nitrogen by volume and only about 21 percent oxygen.

In addition to existing as a gas, oxygen can exist as a liquid and as a solid. Liquid oxygen is pale blue in color. It flows like water, and weighs 9.52 pounds per gallon.

Liquid oxygen, commonly referred to as LOX, is normally obtained by a combined cooling and pressurization process. When the temperature of gaseous oxygen is lowered to -182° F under about 720 psi pressure, it will begin to form into a liquid. When the temperature is lowered to -297° F, it will remain a liquid under normal atmospheric pressure.

Once converted into a liquid, oxygen will remain in its liquid state as long as the temperature is maintained below -297° F. The liquid has an expansion ratio of about 862 to 1, which means that one volume of liquid oxygen will expand about 862 times when converted to a gas at atmospheric pressure. Thus, 1 liter of liquid oxygen produces about 862 liters of gaseous oxygen.

Until a few years ago, all oxygen carried in naval aircraft was in the gaseous state. As flight durations increased, however, it was found that weight and space problems involved with carrying increasing amounts of gaseous oxygen were becoming intolerable. Liquid oxygen has proven the answer to these problems. In its liquid state, oxygen can be "packed" into containers small and light enough to be carried even in fighter type aircraft without weight and space penalty.

In the aircraft, oxygen in the liquid state is carried in a container called a converter. This is a double-walled, vacuum-insulated container similar to the common Ther[illegible]s bottle. The converter is equipped with the ne[illegible]ssary valves and tubing for vaporizing the liquid and warming the gas to cockpit temperatures prior to breathing.

TYPES OF OXYGEN

Aviators breathing oxygen (MIL-O-27210D) is supplied in two types (I and II). Type I is gaseous oxygen and type II is liquid oxygen. Oxygen procured under this specification is required to be 99.5 percent pure. The water vapor content must not be more than 0.02 milligrams per liter when tested at 70° F and at sea level pressure. This is practically bone dry.

Technical oxygen, both gaseous and liquid, is procured under specification BB-0-925A. The moisture content of technical oxygen is not as rigidly controlled as is breathing oxygen; therefore, the technical grade should never be used in aircraft oxygen systems.

The extremely low moisture content required of breathing oxygen is not to avoid physical injury to the body, but to insure proper operation of the oxygen system. Air containing a high percentage of moisture can be breathed indefinitely without any serious ill effects. The moisture affects the aircraft oxygen system in the small orifices and passages in the regulator. Freezing temperatures can clog the system with ice and prevent oxygen from reaching the user. Therefore, extreme precautions must be taken to safeguard against the hazards of water vapor in oxygen systems.

HANDLING/SAFETY PRECAUTIONS

The pressure in gaseous oxygen supply cylinders should not be allowed to fall below 50 psi. If the pressure falls much below this value, moisture is likely to accumulate in the cylinder and could be introduced into the oxygen system of the aircraft, causing component malfunction.

All oxygen under pressure is potentially very dangerous if handled carelessly. Personnel servicing or maintaining oxygen systems and components must be meticulously careful about preventing grease, oil, hydraulic fluid, or similar hydrocarbons as well as other dirt and contamination from coming in contact with lines, hoses, fittings, and equipment. If, because of hydraulic leaks or some other unpreventable malfunction, components of the oxygen system do become contaminated (externally), they should be cleaned using only approved oxygen system cleaning compounds. While some Maintenance Instructions Manuals specify the use of a variety of cleaning compounds such as Anti-icing fluid MIL-F-5566, isopropyl alcohol, trichlorethylene solvent MIL-T-7003, etc., the preferred compound is Oxygen System Cleaning Compound conforming to Military Specification MIL-C-8638 or Ultra Clean Solvent Cleaning Compound (Type I, Trichlorotrifluoroethane) conforming to Military Specification MIL-C-81302B.

CAUTION: Under no circumstances should a non-approved cleaning compound be used on any oxygen lines, fittings, or components.

When handling oxygen cylinders the valve protection cap should always be in place. Before removing the cap and opening the valve insure that the cylinder is firmly supported. A broken valve may cause a pressurized cylinder to be propelled like a rocket.

DO NOT use oxygen in systems intended for other gases or as a substitute for compressed air.

Cylinders being stored for use on gaseous oxygen servicing trailers or any other use must always be properly secured. Do not handle cylinders or any other oxygen equipment with greasy hands, gloves, or other greasy materials. The storage area should be located so that oil or grease from other equipment cannot be accidentally splashed or spilled on the cylinders.

Additional precautions that have more application to liquid oxygen handling are provided in chapter 8. Precautions pertaining to the servicing of both gaseous and liquid oxygen systems are provided in chapter 10.

RESPONSIBILITIES OF THE AME

Personnel of the AME rating are responsible for servicing and maintaining aircraft oxygen systems, both gaseous and liquid. AME's are also responsible for a preoperational check of oxygen servicing equipment.

The AME3 must be familiar with the operating principles of aircraft oxygen systems and oxygen servicing equipment. He should be able to service oxygen systems, ground check them for proper operation, locate and repair leaks, and perform purging operations when necessary.

In addition to the foregoing responsibilities, the AME2 should be familiar with the operating principles of oxygen system components, be able to remove and install system components, and maintain oxygen servicing equipment.

GASEOUS OXYGEN SYSTEM COMPONENTS

Gaseous oxygen systems are used primarily in large, multiplace aircraft where space and weight limitations are less important items and the systems are used only periodically.

Basically, all gaseous oxygen systems consist of the following:

1. Containers (cylinders) for storing the oxygen supply.

2. Tubing to conduct the oxygen from the main supply to the user(s).
3. Various valves for directing the oxygen through the proper tubing.
4. A metering device (regulator) to control the flow of oxygen to the user.
5. A gage (or gages) for indicating the oxygen pressure.
6. A mask to direct the oxygen to each user's respiratory system.

CYLINDERS

Gaseous oxygen cylinders used in naval aircraft systems are generally high-pressure, nonshatterable cylinders. The term shatterproof or nonshatterable indicates that the cylinder is designed to resist shattering when punctured by a foreign object, such as gunfire, at a pressure of 1,800 psi. The resistance to shattering is generally achieved by the use of a heat-treated alloy or wire wrapping applied to the outside of the cylinder. The two most common cylinder sizes are—514-cubic inch and 295-cubic inch.

The chief advantage of the high-pressure cylinder is that it minimizes space utilized for storing gaseous oxygen. A secondary advantage is if a cylinder charged with oxygen is punctured, the steel around the entrance hole burns in the oxygen atmosphere producing an extremely hot, long flame of short duration. All high-pressure oxygen cylinders are painted green in accordance with the established color codes provided in MIL-STD-101A.

Cylinders come equipped with either a manually operated handwheel valve or an automatic self-opening valve. (See figs. 7-1 and 7-2.)

The oxygen cylinder and handwheel valve assembly (fig. 7-1) consists of a shatterproof steel cylinder and handwheel-operated seat valve for releasing the contents of the cylinder. The handwheel has four 5/16-inch diameter holes for the attachment of remote-operation equipment if needed.

The valve is equipped with a fusible metal safety plug and a safety disc to release the contents of the cylinder should the pressure become excessive because of high temperatures. The safety plug is filled with a fusible metal designed to melt at temperatures ranging from 208° to 220° F.

The cylinder and valve assembly is connected to the oxygen tubing by silver soldering the tubing to a coupling nose and securing the nose to the valve outlet with a coupling nut.

The self-opening (automatic) oxygen cylinder valve is automatically opened when it is connected to the oxygen line. The use of this type of valve permits remote location of the oxygen cylinder to places less vulnerable during combat and more readily accessible for servicing.

REGULATORS

The success or failure of high-altitude flight depends primarily on the proper functioning of the oxygen breathing regulator. Acting as a metering device, the regulator is the very heart of the oxygen system. To perform successfully in an aircraft system, a regulator must deliver the life-supporting oxygen in the quantities demanded throughout its entire range of operation.

Although personnel of the PR rating are primarily responsible for maintenance of regulators, the AME is responsible for performing operational checks in the aircraft and for removal and installation. In other words, the AME removes a malfunctioning regulator from the aircraft and delivers it to the regulator shop where the PR determines the trouble and makes the necessary repairs. When the trouble is corrected, the AME reinstalls the regulator in the aircraft.

Regulators may be grouped into the following general types or groups:

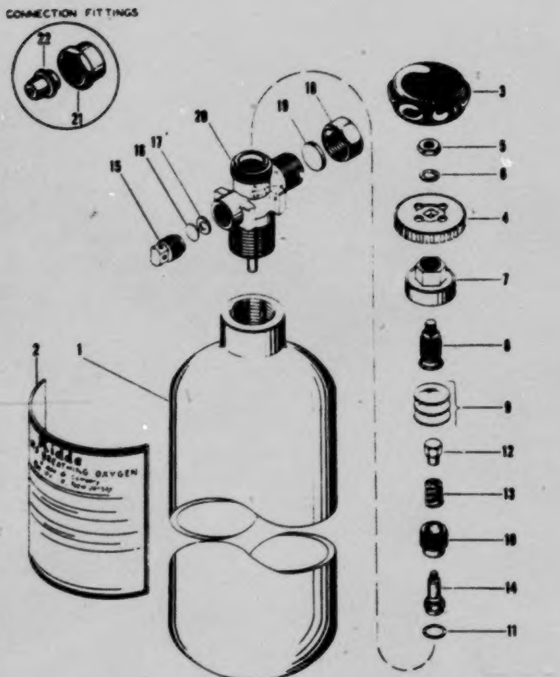
Diluter demand regulators.

Automatic positive pressure diluter demand regulators.

Miniature positive pressure 100% demand type regulators. (This regulator is designed especially for use with low-pressure liquid oxygen systems in aircraft equipped with ejection seats, and is described in chapter 8 of this training manual.) Other regulators are described on the following pages.

Diluter Demand Regulators
(2858 Series)

Demand type regulators deliver oxygen to the lungs in response to the suction created by normal breathing, that is, on demand. Each time the user inhales, a valve in the mask closes and one in the regulator opens. When the user exhales the process is reversed. These movements automatically stop and start the flow of oxygen so that the user gets as much as he demands and no more.



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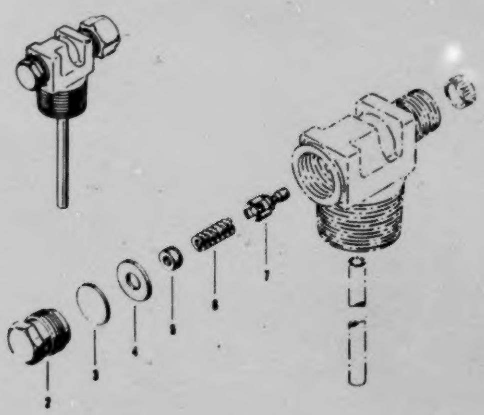
1. Cylinder
2. Label—Instruction on Walter Kidde cylinders.
3. Handgrips.
4. Handwheel.
5. Nut, handwheel.
6. Washer, lock extension teeth, bronze, No. 10.
7. Caps, valve.
8. Stem, upper.
9. Diaphragm (set of 3).
10. Bushing.
11. Gasket, bushing.
12. Cap, spindle.
13. Spring.
14. Seat, valve.
15. Plug, safety.
16. Disc, safety.
17. Washer, safety disc.
18. Cap, outlet.
19. Washer, outlet cap.
20. Body, valve.
21. Nut, coupling.
22. Nose, coupling.

Figure 7-1.—Gaseous oxygen cylinder and handwheel valve assembly.



AM. 119

1. Self-opening high-pressure oxygen valve assembly.
2. Safety plug assembly.
3. Safety disc.
4. Disc washer.
5. Spring nest.
6. Spring.
7. Assembly check.

Figure 7-2.—Self-opening oxygen cylinder valve.

In order to conserve the supply of oxygen it is automatically diluted in the regulator with suitable amounts of atmospheric air. This dilution takes place at all altitudes below 34,000 feet. Above 34,000 feet 100% oxygen is supplied.

Diluter Demand Oxygen Regulators, Models 2858-A1, 2858-A1A, 2858-B1, and 2858-C1 are designed to be operated on an input pressure of 0 to 2,000 psi and to give diluted, or when necessary 100 percent oxygen upon demand, up to a ceiling of 35,000 feet.

This ceiling can be exceeded by 2,000 feet during emergencies for short periods of time only. These regulators are suction-diaphragm operated. They automatically mix varying quantities of air and oxygen, the ratio depending upon the altitude.

Except for a few minor modifications, the 2858 series regulators are all of the same basic design. Figure 7-3 illustrates the 2858-A1. The regulator has an independent oxygen emergency

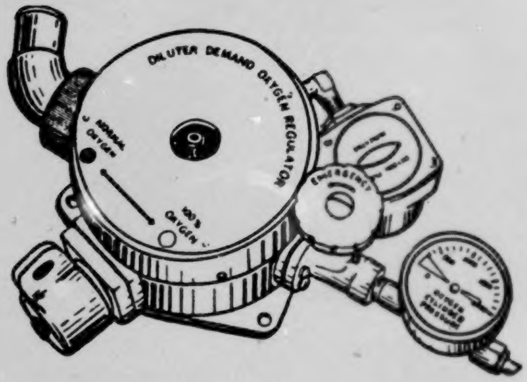


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Figure 7-3.—Diluter Demand Oxygen Regulator, Model 2858-A1.

valve. When the red emergency knob is turned counterclockwise, a large continuous stream of oxygen is allowed to bypass the entire regulator mechanism and enter the elbow. A directional arrow indicates the ON and OFF positions of the knob. For emphasis, the directional arrow is marked with luminous or radium paint.

The essential feature of diluter demand type regulators is the diaphragm-operated demand valve, which opens by slight suction on the diaphragm when the user inhales, and which closes when the user exhales. A reducing valve located upstream from the demand valve provides a controlled working pressure. Downstream from the demand valve is the diluter mechanism, which consists of a sealed, evacuated bellows (aneroid assembly) that is used to control the atmospheric air inlet.

When the diluter lever is positioned to "NORMAL OXYGEN" the user gets mainly atmospheric air at ground level, with very little added oxygen. As the altitude is increased, the air inlet is gradually closed by the bellows, thus providing a higher concentration of oxygen until at about 34,000 feet, the air inlet is completely closed and the user gets 100% oxygen. As the aircraft descends, naturally this process is reversed.

The diluter knob can be set to give 100% oxygen at any altitude. At moderate altitudes this will cause the oxygen supply to be used much more rapidly than normal. The diluter knob should be set at "NORMAL OXYGEN" for all routine operations. It is set at "100% OXYGEN" when oxygen is being used because of wounds, as part of the treatment for shock, to protect against exhaust gases or other noxious gases in the aircraft, to avoid bends and chokes, or to correct a feeling of lack of oxygen.

If the user's mask is properly fitted and all equipment properly functioning, there should be no feeling of lack of oxygen. If the user must select 100% oxygen on a multiplace aircraft, the aircraft commander should be so informed.

The emergency valve provided on the regulator, when open, provides a steady stream of pure oxygen to the user's mask, regardless of altitude. The emergency position is selected in any of the following emergencies:

Hypoxia or unconsciousness of any crewmember.

Sudden serious leakage in the user's oxygen mask or mask to regulator tubing.

Malfunction of the regulator.

When it becomes necessary to utilize the emergency mode of the regulator, the plane commander/pilot should descend to an altitude not requiring oxygen as soon as it is practicable. Use of the emergency position will exhaust the oxygen supply in a very short time.

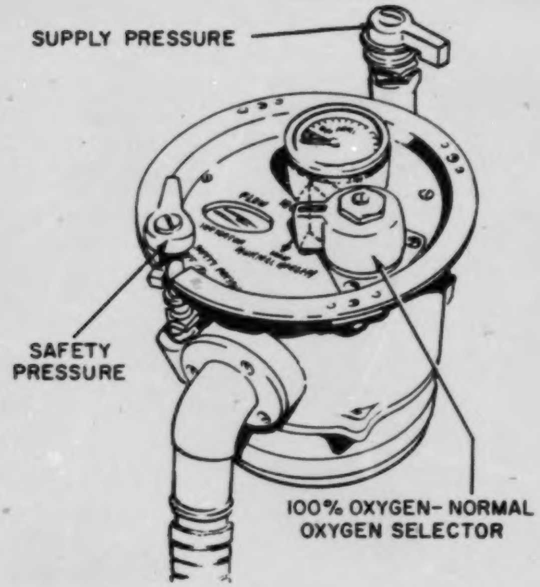
In all cases it is important to use the prescribed mask-regulator combination since they are not always interchangeable. For example, the A-14 mask should be used with the regulator illustrated in figure 7-3 in order that the EMERGENCY valve may be used with safety in an emergency. A continuous flow of oxygen to a type A-13A mask will prevent the user from opening the compensated exhalation valve and may allow dangerous pressure to build up in the lungs.

The regulator illustrated in figure 7-3 is typical of the type found on aircraft walkaround oxygen cylinders. The physical appearance of such regulators will vary some but the operation is nearly identical in all models. On several models "NORMAL OXYGEN" is simply labeled "ON" and "100% OXYGEN" is labeled "OFF".

The information provided on the modes of operation for the regulators in this section should enable the AME to successfully perform regulator operational checks which are discussed in greater detail under the maintenance section of this chapter.

Automatic Positive Pressure Diluter Demand Regulators

The Automatic Positive Pressure, Diluter Demand Oxygen Regulators, Models such as 2867, 2872, 2873, and 2874, are used in high-altitude flight to supply oxygen under pressure to the user. The regulator illustrated in figure 7-4 is the 2867-B2.



AM.121

Figure 7-4.—Automatic Positive Pressure Diluter Demand Oxygen Regulator, Model 2867-B2.

It automatically mixes air and oxygen at a ratio depending on altitude and delivers this mixture to the user on inhalation. A pressure breathing mask such as the type A-13A, must be used with these regulators. With a tight mask, this regulator (supplying 100% oxygen) can be used up to an altitude of 50,000 feet, under emergency conditions. At altitudes above 35,000 feet, positive pressure is supplied to the user.

DESCRIPTION.—Figure 7-5 illustrates an operational schematic of the Model 2867-B2 regulator. The regulator is in the oxygen system of the aircraft between the oxygen supply and the user's mask. Oxygen is admitted to the regulator through the inlet fitting and filter. It passes through a pressure reducer assembly which drops cylinder pressure to a valve between 40-60 psi when there is a flow through the regulator. Air is admitted to the regulator through the air valve (100% and NORMAL OXYGEN selector valve) located on the panel of the regulator.

The knob marked "OXYGEN SUPPLY" controls the oxygen supply from the cylinders to the regulator. The pressure reducer assembly consists of a springloaded bellows which is recessed in the housing within the pressure reducer assembly. Oxygen flows through the reducer assembly and into the upper part of the demand valve chamber where further flow is prevented by the normally closed demand valve.

The demand valve basically consists of a stem which is connected to the demand valve lever. The opposite end of the demand valve lever is attached to the diaphragm. When the mask wearer inhales, the diaphragm moves inward and causes the demand valve to open.

The flow indicator assembly consists of a diaphragm which is linked to a lever and plate blinker mechanism. Oxygen pressure in the flow indicator channel causes the diaphragm to move outward and through linkage to the blinker portion of the indicator causes the black portion of the indicator to come into view with each breath of the mask wearer.

On demand, the oxygen flows from the demand valve and into the injector assembly, causing the injector nozzle to compress a spring. The small nozzle opening causes a pressure drop which, in turn, causes the light spring-loaded air check valve to open and admit air. The air is carried along with the oxygen, and delivered to the mask. The air-to-air oxygen proportion varies with the altitude. In the presence of deep inhalation by the user, the injector nozzle moves forward against the pressure of the spring and uncovers two slots in the injector sleeve to permit a greater flow of oxygen to the interior of the regulator case and subsequently to the mask.

The air aneroid and check valve assembly, located beneath the air valve lever, contains an aneroid bellows which expands gradually as the atmosphere becomes rarefied (altitude increases). As the aneroid expands, it progressively decreases the amount to which the air valve may open until at an altitude of approximately 32,000 feet, the air passage through the regulator is completely closed. The check valve consists of a spring-loaded disc pressing against a seat at the

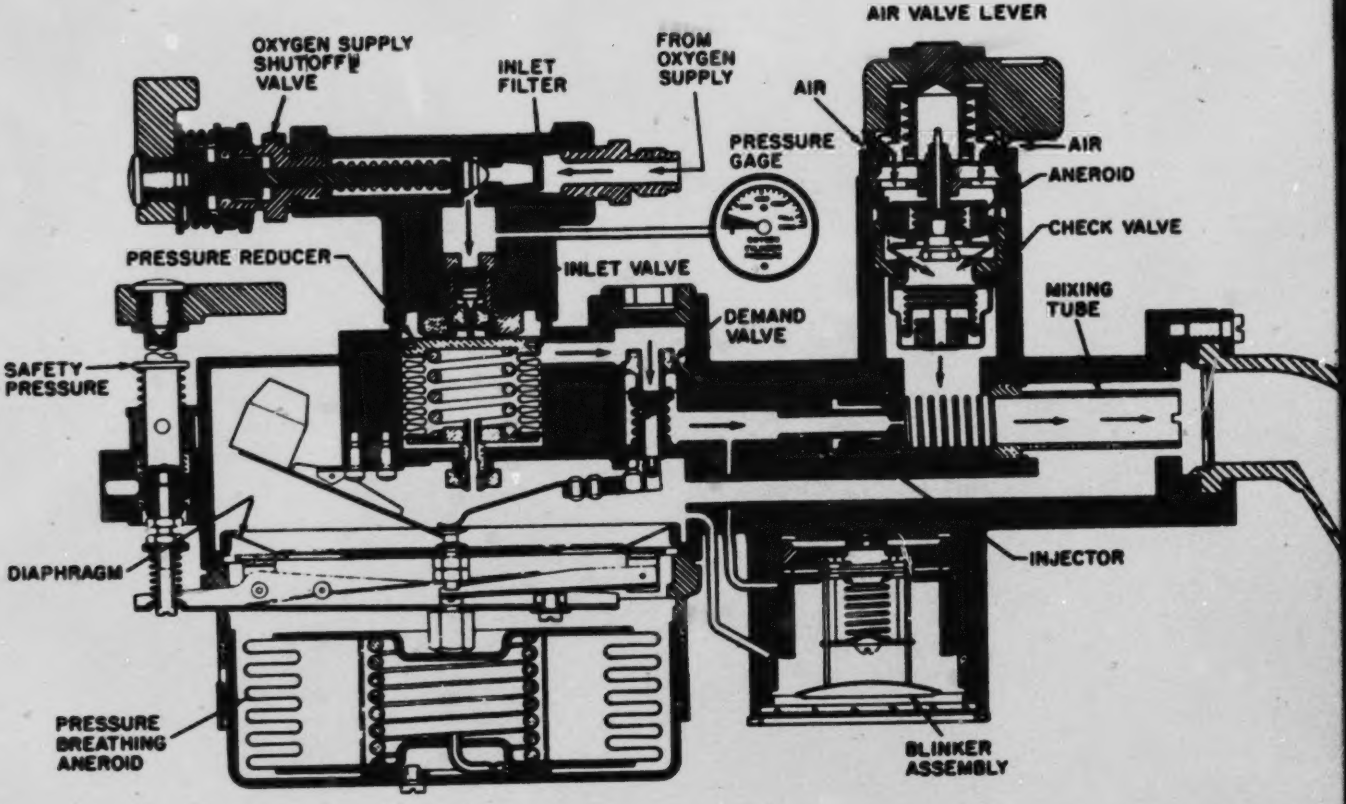
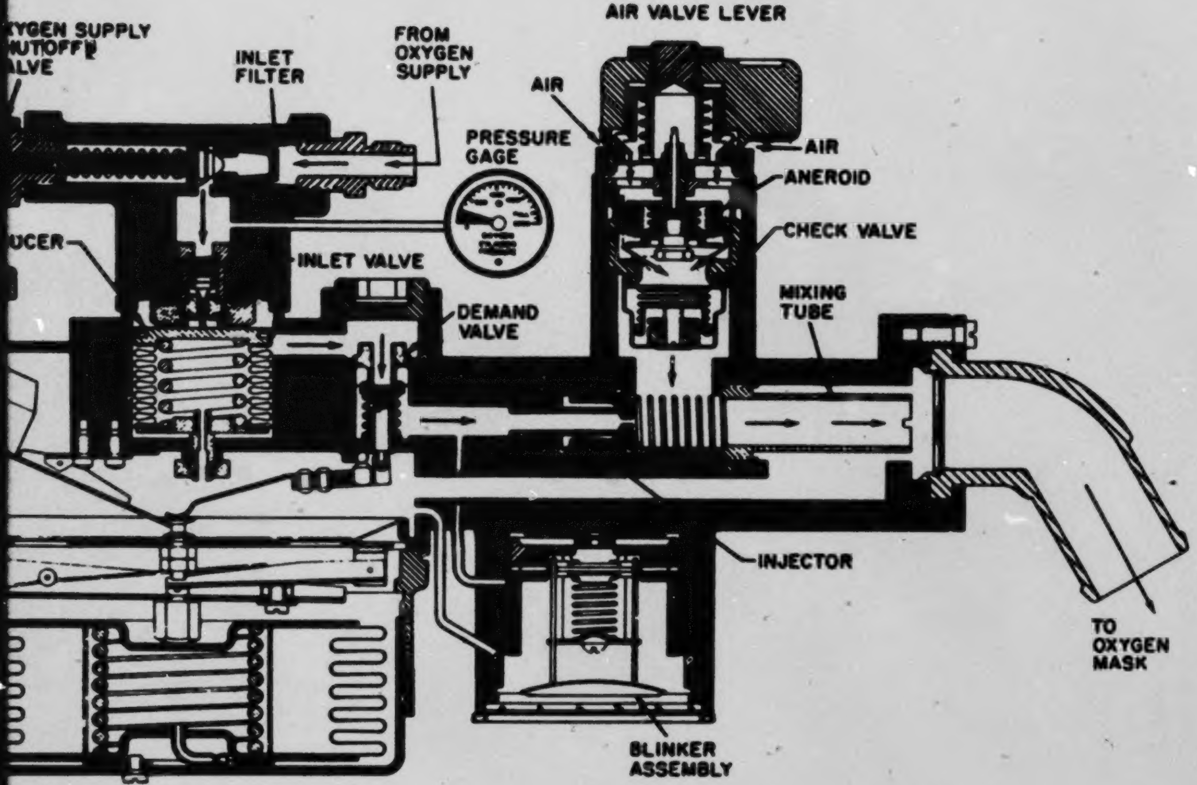

OXYGEN SUPPLY SHUTOFF VALVE
INLET FILTER
FROM OXYGEN SUPPLY
AIR VALVE LEVER
AIR
AIR
PRESSURE GAGE
ANEROID
CHECK VALVE
PRESSURE REDUCER
INLET VALVE
DEMAND VALVE
MIXING TUBE
SAFETY PRESSURE
DIAPHRAGM
INJECTOR
PRESSURE BREATHING ANEROID
BLINKER ASSEMBLY

Figure 7-5.—Diluter demand regulator, operational schematic-Model 2867-B2.


XYGEN SUPPLY
HUTOFF
ALVE
INLET FILTER
FROM OXYGEN SUPPLY
AIR VALVE LEVER
AIR
PRESSURE GAGE
AIR
ANEROID
CHECK VALVE
UCER
INLET VALVE
DEMAND VALVE
MIXING TUBE
INJECTOR
TO OXYGEN MASK
BLINKER ASSEMBLY

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igure 7-5.—Diluter demand regulator, operational schematic-Model 2867-B2.

bottom of the aneriod housing. Pressure of this disc against the seat permits air to pass through the check valve assembly only when there is a pressure drop in the mixing tube (on inhalation).

The counterweight lever assembly is part of the linkage system connecting the diaphragm and the demand valve lever. The counterweight functions to depress the spring-loaded end of the demand valve lever thus opening the demand valve to permit a greater flow of oxygen. Under exceptional demand conditions the demand valve lever can also be depressed by rotation of the safety pressure arm, as required, to permit a greater flow of oxygen at a positive pressure. The counterweight helps the user to inhale when positive gravitational forces are encountered.

The pressure breathing aneroid assembly begins to expand at a cabin altitude of approximately 35,000 feet. When expanding, the aneroid creates a force on the diaphragm which, in turn, opens the demand valve. Oxygen flows through the demand valve and causes the pressure in the mask to buildup until the internal force on the diaphragm balances the force created by the aneroid. At this time the demand valve will close. Under pressure breathing conditions, this sequence provides continuous and constant pressure at the mask during the breathing cycle. The degree of pressure will depend upon the cabin altitude.

MD-1 and MD-2 Oxygen Regulators

The MD-1 oxygen regulator (fig. 7-6) is being used in several new multiplace naval aircraft. This regulator is designed for use in gaseous systems, which utilize a pressure reducer, and in liquid oxygen systems. The MD-2 is used in high-pressure systems. The MD-1 is described in the following paragraphs.

The MD-1 regulator is equipped with a relief valve, flow indicator, panel lighting dial, a supply pressure gage, and three hand-operated toggles. The relief valve, integral with the regulator, relieves excess pressure built up at the outlet. A small oblong shaped window area located on the left side of the regulator panel indicates the flow of oxygen through the regulator by a visible blinking action. A pressure gage, located on the right side of the panel, indicates inlet pressure to the regulator.

The regulator has three control toggles. A supply toggle, located in the lower right corner, is used to control the supply of oxygen to the regulator. The diluter toggle, located in the lower center of the panel, has two positions—100% OXYGEN and NORMAL OXYGEN. In the 100% OXYGEN position, the regulator delivers 100 percent oxygen upon inhalation by the user. In the NORMAL OXYGEN position, the regulator delivers a mixture of air and oxygen, with the air content decreasing until at a cabin altitude of approximately 30,000 feet is reached. Above this altitude, 100% oxygen is delivered to the mask upon inhalation.

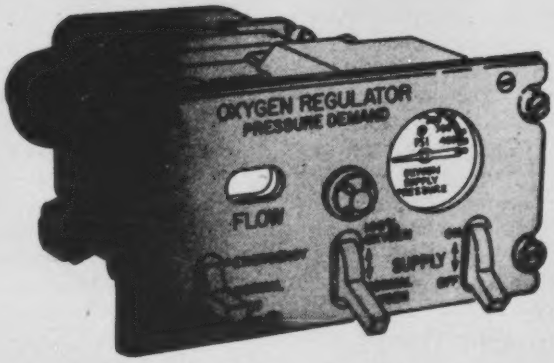

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Figure 7-6.—MD-1 oxygen regulator.

The emergency pressure control toggle, located on the left portion of the panel, has three positions—EMERGENCY, NORMAL, and TEST MASK. The EMERGENCY position delivers positive pressure to the outlet at altitudes where positive pressure is not automatically delivered. In the TEST MASK position, oxygen is delivered to the mask under pressure too high to breathe and is used for checking the fit of the mask. The switch must be in the NORMAL position to assure normal system operation.

The operating pressure of the MD-1 regulator is 50 to 500 psi. The MD-2 regulator is identical in every respect to the MD-1, except for the operating pressure, which ranges from 50 to 2,000 psi.

TUBING

Two types of tubing are used in aircraft oxygen systems. Low-pressure aluminum alloy tubing may be used in lines carrying pressures up to 450 psi. High-pressure copper tubing is used in lines carrying pressures above 450 psi.

NOTE: Some of the newer naval aircraft are equipped with high-pressure oxygen lines made of aluminum alloy.

Lines running from the filler valve to each of the cylinders are referred to as filler lines. Those running from the cylinders to the regulators are called distribution (or supply) lines.

Oxygen lines, like all other lines in the aircraft, are identified by strips of colored tape. The strips of tape are wrapped around each line near each fitting and at least once in each compartment through which the line runs. The color code for oxygen lines is green, with the words BREATHING OXYGEN printed repeatedly on the green band. (See fig. 3-15 in ch. 3.)

High-Pressure Tubing

Resistance to fatigue failure is an important factor, especially when it is realized that the line pressure in a high-pressure system will at times exceed 1,800 psi and at other times be as low as 300 psi. Because of this, there is a certain amount of expansion and contraction going on all the time, even temperature changes add to the condition. This condition causes "metal fatigue" and is to be guarded against in both the design and the construction specifications for tubing. Steps are taken during installation to prevent fatigue failure of the tubing. Tubing is bent in smooth coils wherever it is connected to an inflexible object, like a cylinder or a regulator. Every precaution that can possibly be taken to prevent the accidental discharge of compressed oxygen because of faulty tubing or a faulty installation is accomplished. Although simple in construction, tubing plays a major role in routing the oxygen from the cylinders to the regulator stations.

High-pressure tubing is usually seamless copper tubing, and is manufactured in accordance with strict specifications. It has an outside diameter of 3/16 inch and a wall thickness of 0.035 inch. For application in high-pressure oxygen installations, copper tubing is type N (soft annealed), and is pressure tested at not less than 3,000 psi.

High-pressure tubing is used between the oxygen cylinder valve and the filler connection in all systems, between the cylinder valve and the regulator inlet in high-pressure systems, and between the cylinder valve and pressure reducer in reduced-high-pressure systems.

In order to connect high-pressure copper tubing, adapters and fittings are silver soldered to the tubing ends. Due to the high pressures involved, the security (leak tightness) of all high-pressure lines relies primarily on a metal-to-metal contact of all its fittings and connections. A fitting properly silver soldered to the end of a length of copper tubing will not come loose or leak.

Some of the later models of naval aircraft utilize aluminum alloy or stainless steel tubing in high-pressure oxygen system installations. Replacement tubing should be manufactured of the same type material as the original tubing or a suitable substitute as specified in the Maintenance Instructions Manual.

Low-Pressure Tubing

Low-pressure tubing adaptable for use in low-pressure lines is considerably different from the type used in high-pressure lines. The material used is aluminum alloy, and the diameter of the tubing is greater. All low-pressure tubing used in oxygen systems is aluminum alloy 5052 tubing and is nonheat-treatable. It is manufactured in seamless, round lengths, and is annealed to provide greater flexibility. Aircraft oxygen systems are fitted with 5/16-, 3/8, and 1/2-inch sizes. Low-pressure tubing is installed from the pressure reducer to the outlets in reduced-high-pressure systems.

VALVES

Various types of valves are installed in gaseous oxygen systems. Among the most commonly used are check valves, pressure-reducing valves, shutoff valves, and a filler valve.

Check Valves

Check valves are installed at various points in the oxygen system. Their purpose is to permit the flow of oxygen in one direction only. Check valves are located in the system so as to prevent the loss of the entire oxygen supply in the event a cylinder or line is ruptured. Various styles of single, dual, and triple check valves are available, as shown in figure 7-7. The arrow (or arrows) embossed on the valve casting indicates the direction of flow through the valve.

Pressure-Reducing Valve

Pressure-reducing valves (or pressure reducers) are used in certain oxygen systems for

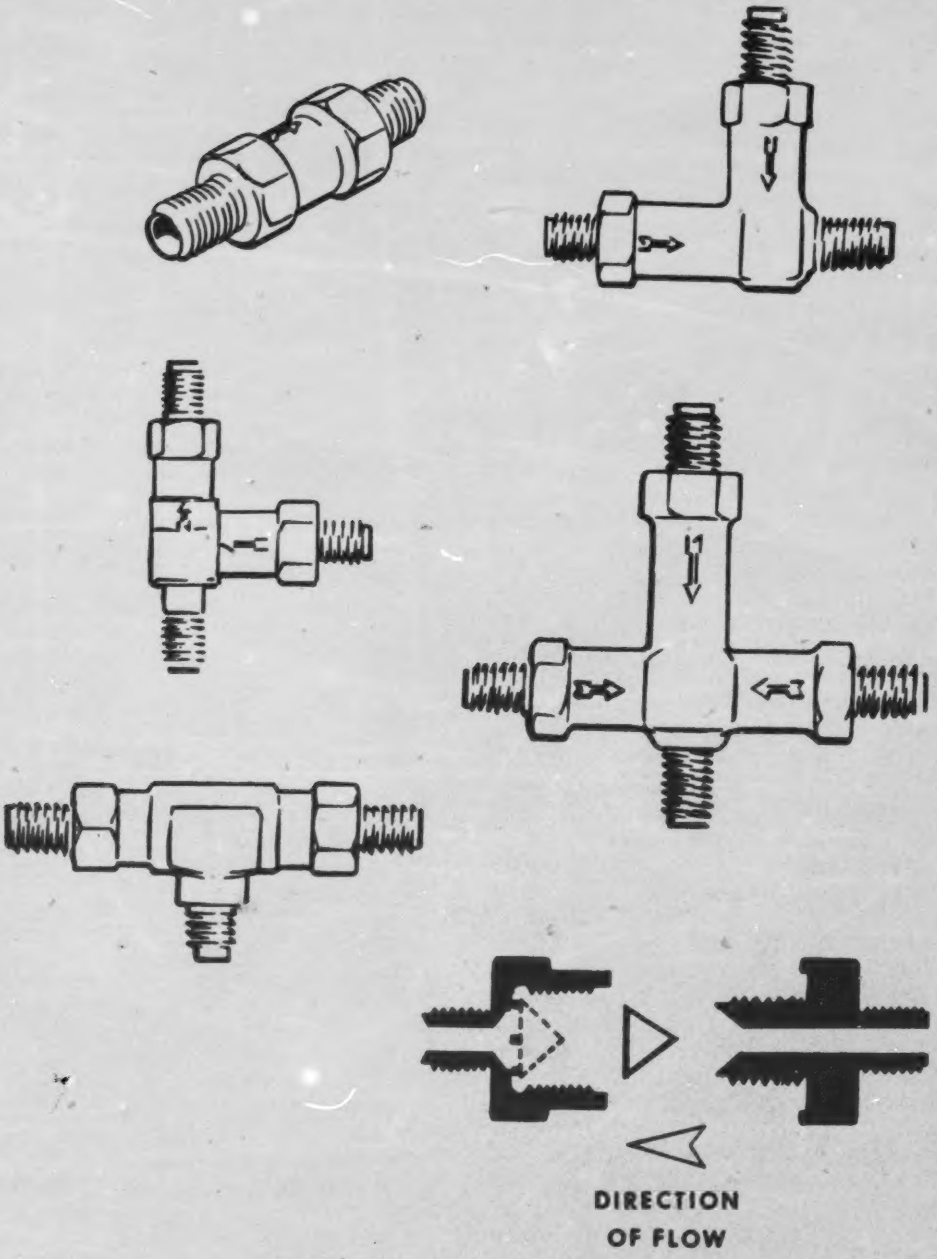
DIRECTION
OF FLOW

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Figure 7-7.—Oxygen system check valves.

the purpose of reducing high cylinder pressure to a low working pressure. In most installations the pressure reducers are designed to reduce the pressure from 1,800 psi to a working pressure of 60 to 70 psi. They are always located in the oxygen distribution lines between the cylinders and flight station outlets. Figure 7-8 illustrates a typical pressure reducer.

Filler Valves

All oxygen systems are so designed that the entire system can be serviced (refilled) through a common filler valve. The filler valve is generally located so that it may be reached by a man standing on the ground or wing. The filler valve contains a check valve which opens during the filling operation and closes when filling is completed. A dust cap keeps out dust, dirt, grease, and moisture.

GAGES

Gages used in gaseous oxygen systems are for the purpose of indicating the oxygen pressure in pounds per square inch (psi). All systems are equipped with at least one gage which indicates the amount of oxygen in the cylinder(s). It also indicates indirectly how much longer the oxygen will last. The volume of any gas compressed in a cylinder is directly proportional to the pressure. If the pressure is half, the volume is half, etc. Therefore, if 900 psi of oxygen remains in an 1,800 psi system, half the oxygen is left.

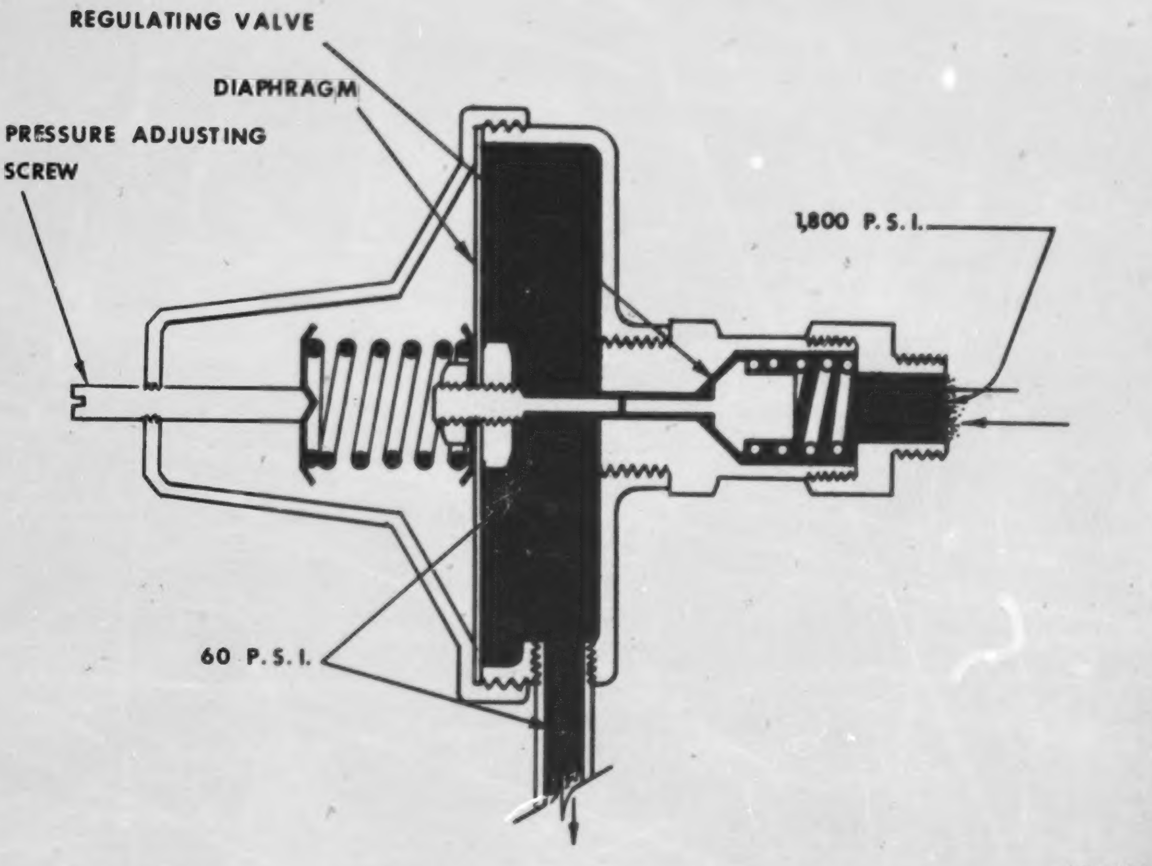

Figure 7-8.—Pressure-reducing valve.

A pressure gage is always mounted at each flight station, usually on the regulator. These gages are calibrated to indicate from 0 to 2,000 psi on high-pressure systems and 0 to 500 psi on low-pressure systems.

TYPICAL GASEOUS OXYGEN SYSTEMS

Naval aircraft equipped with high-pressure type systems are designed to be filled to approximately 1,800 psi, depending on the ambient temperature. On some systems the high pressure is reduced to a working pressure of 60 to 70 psi by a pressure reducer in the distribution lines. On other systems the high cylinder pressure is reduced to working pressure within the regulator. Systems equipped with pressure reducers are usually referred to as reduced-high-pressure systems.

REDUCED-HIGH-PRESSURE SYSTEM

The reduced-high-pressure oxygen system used on the P-3 aircraft is shown in figure 7-9. In this system oxygen is stored in three high-pressure cylinders. The oxygen supplies three regulators, one each for the pilot, copilot, and the plane captain.

NOTE: Since the P-3 is a pressurized aircraft, the oxygen system is considered as a supplementary or emergency life-support system. The cabin crewmen are supplied with "walkaround systems."

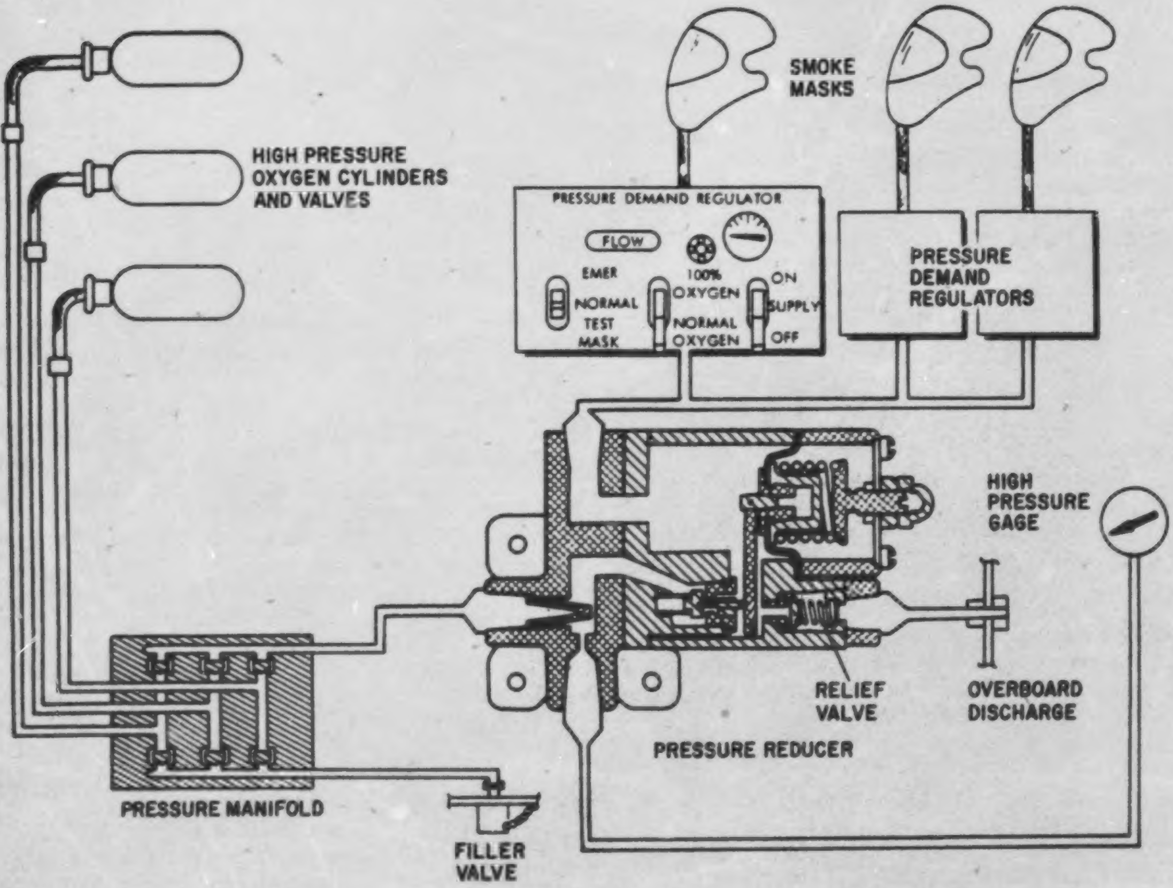
SMOKE MASKS
HIGH PRESSURE OXYGEN CYLINDERS AND VALVES
PRESSURE DEMAND REGULATOR
FLOW
EMER
NORMAL
TEST MASK
100% OXYGEN
NORMAL OXYGEN
ON
SUPPLY
OFF
PRESSURE DEMAND REGULATORS
HIGH PRESSURE GAGE
RELIEF VALVE
OVERBOARD DISCHARGE
PRESSURE REDUCER
PRESSURE MANIFOLD
FILLER VALVE

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Figure 7-9.—Reduced-high-pressure oxygen system schematic.

System Operation

The pressure manifold, which is equipped with internal check valves, receives oxygen flow from the cylinders, manifolds the flow into a common line, and routes it to the pressure reducer. The manifold assembly also connects to a filler line, allowing the three cylinders to be recharged simultaneously from an external supply. The pressure reducer decreases the pressure to 65 psi.

Incorporated on the low-pressure side of the pressure reducer is a relief valve which connects through tubing to an overboard discharge indicator. In the event of excessive pressure developing within the low-pressure section of the pressure reducer, the excess pressure will flow through the relief valve and out the dump line. This flow will rupture the green disc in the discharge indicator, giving a visual indication of a malfunctioning pressure reducer.

A line from the high-pressure side of the pressure reducer connects to a gage in the cockpit. This gage gives the pilot an indication of pressure in the three storage cylinders.

The oxygen flows from the low-pressure side of the reducer to the three regulators. A flexible hose attached to each regulator provides for ready attachment of the oxygen mask.

HIGH-PRESSURE SYSTEM

The oxygen system with its components illustrated in figure 7-10 is used on the T-39D aircraft.

High-pressure oxygen in the storage cylinders is sensed by a transmitter immediately downstream from the single high-pressure outlet. This pressure is transmitted to an indicating gage on the left of the pilot's instrument panel. The pressure-reducing valve reduces the cylinder pressure (1,800 psi) to 350 (±50) psi before it enters the pressurized cabin area. Oxygen is supplied directly to the six oxygen regulators in the cockpit and aft cabin areas.

The regulators automatically supply a proper mixture of oxygen and air (upon demand) at all cabin altitudes to 27,000 feet, at which altitude 100% oxygen is supplied (pressure-fed). It incorporates a diluter lever, an emergency toggle lever, a pressure gage, a flow indicator, and an oxygen supply lever. The diluter lever is used to select either normal oxygen under all normal flight conditions or 100% oxygen during emergencies, such as when there is smoke or fuel fumes in the cockpit.

PORTABLE OXYGEN SYSTEMS

Portable oxygen systems include walkaround cylinders, survival kit units, and bailout units. These systems are used primarily to maintain crew functions in the event of failure of the fixed oxygen systems. The survival kit oxygen system also performs the same function during descent after bailout. All of these are small, lightweight, high-pressure, self-contained gaseous systems which are readily removed from the aircraft.

WALKAROUND CYLINDERS

Walkaround cylinders are standard equipment on many transport, patrol, and early warning aircraft, and are used separately or in addition to a permanently installed oxygen system. Each system consists of a reducer and regulator assembly mounted directly on a small oxygen cylinder.

Figure 7-11 illustrates a high-pressure walkaround oxygen system. A 96-, 205-, or 295-cubic inch capacity, 1,800 psi cylinder is equipped with a regulator which is connected to the cylinder with a short coiled length of copper tubing. A short flexible breathing tube, clamped to the outlet of the regulator at one end and fitted with a connector at the other end, provides the necessary assembly for the attachment of the demand mask tube. Straps fastened to the cylinder bracket provide the means for securing the unit to the user's seat or part of the aircraft's structure. The cylinder bracket may be placed horizontally or stood on end while in use. The straps can be used as a handle to facilitate carrying it from place to place. Because of its weight, the walkaround unit should not be carried by its breathing tube, regulator, or copper tubing. A 205-cubic inch capacity portable high-pressure unit weighs approximately 20 pounds, 12 ounces.

The high-pressure walkaround unit is equipped with a pressure gage threaded into the regulator inlet, which affords the means of checking the remaining supply of oxygen in the cylinder. These units cannot be refilled from the aircraft's system, but must be serviced by portable and/or permanent type oxygen recharge equipment. This requires the loosening of the bracket and disconnecting the copper tubing at the cylinder valve, which is the handwheel type.

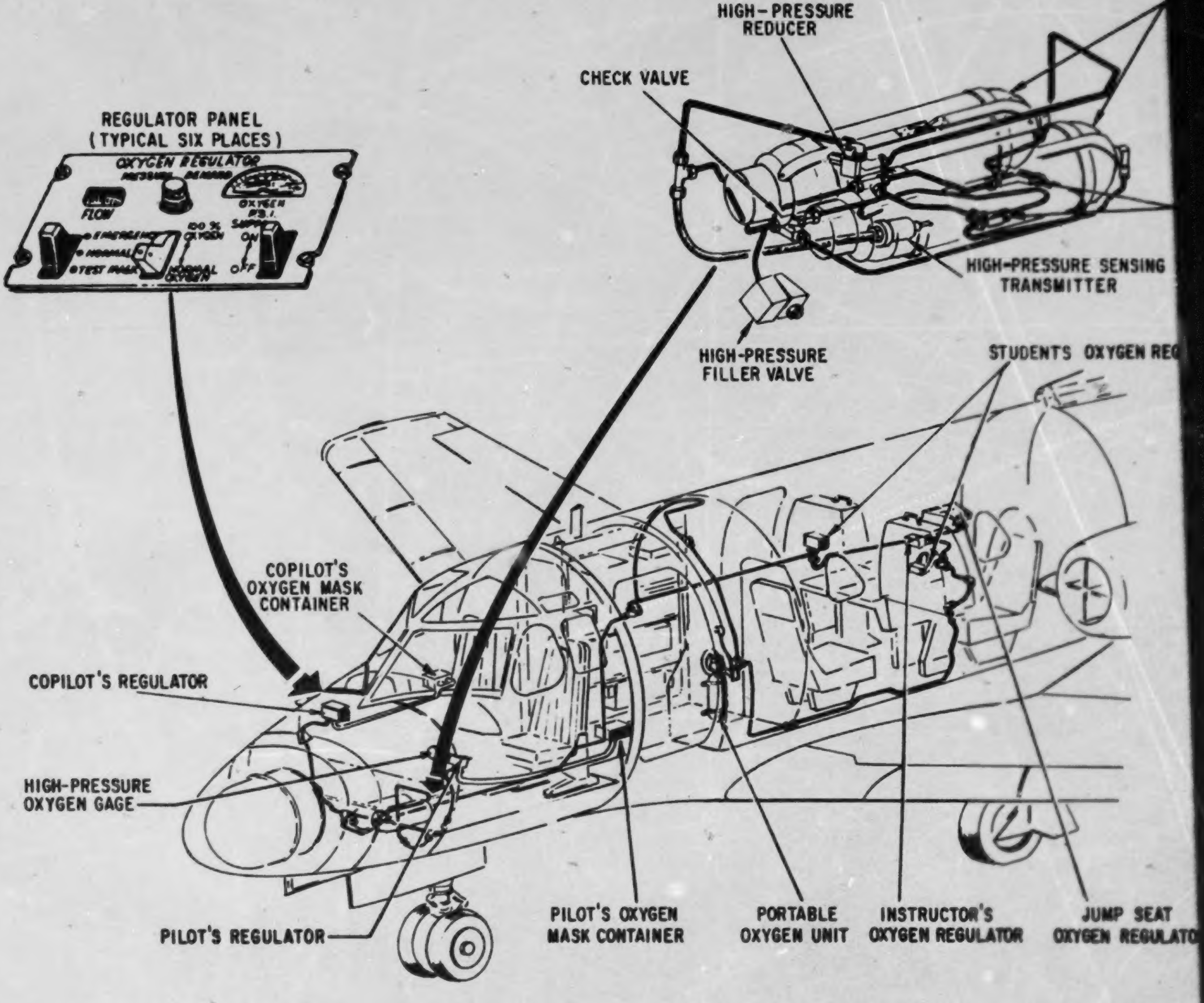
HIGH - PRESSURE
REDUCER
CHECK VALVE
REGULATOR PANEL
(TYPICAL SIX PLACES)
OXYGEN REGULATOR
PRESSURE DEMAND
FLOW
OXYGEN
P.S.I.
SUPPLY
ON
OFF
100 %
OXYGEN
NORMAL
OXYGEN
EMERGENCY
NORMAL
TEST MASK
HIGH-PRESSURE SENSING
TRANSMITTER
HIGH-PRESSURE
FILLER VALVE
STUDENTS OXYGEN REG
COPILOT'S
OXYGEN MASK
CONTAINER
COPILOT'S REGULATOR
HIGH-PRESSURE
OXYGEN GAGE
PILOT'S REGULATOR
PILOT'S OXYGEN
MASK CONTAINER
PORTABLE
OXYGEN UNIT
INSTRUCTOR'S
OXYGEN REGULATOR
JUMP SEAT
OXYGEN REGULATO

Figure 7-10.—High-pressure oxygen system.

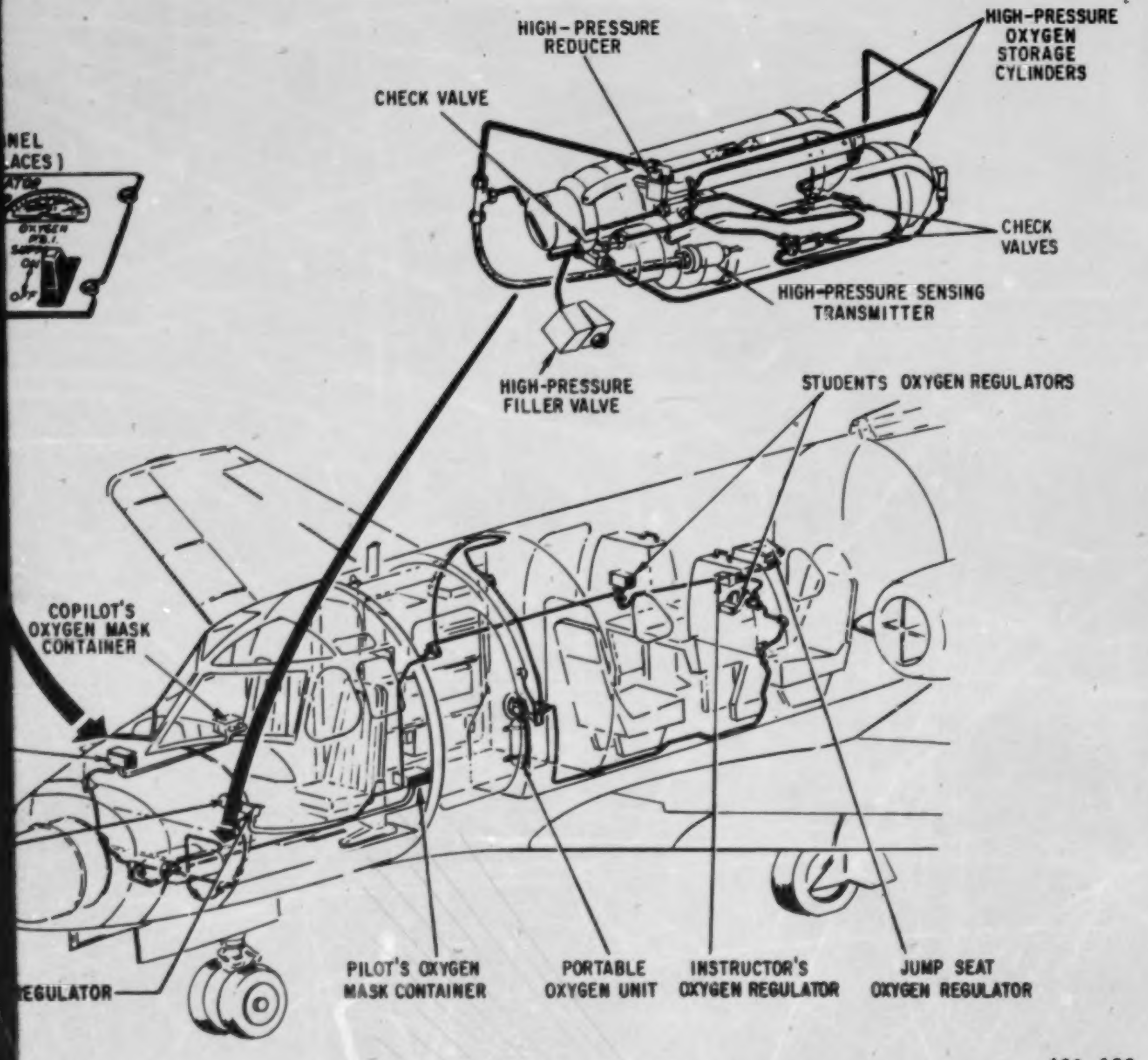
HIGH-PRESSURE REDUCER
HIGH-PRESSURE OXYGEN STORAGE CYLINDERS
CHECK VALVE
NEL
LACES)
OXYGEN
SUPPLY
ON
OFF
CHECK VALVES
HIGH-PRESSURE SENSING TRANSMITTER
HIGH-PRESSURE FILLER VALVE
STUDENTS OXYGEN REGULATORS
COPILOT'S OXYGEN MASK CONTAINER
REGULATOR
PILOT'S OXYGEN MASK CONTAINER
PORTABLE OXYGEN UNIT
INSTRUCTOR'S OXYGEN REGULATOR
JUMP SEAT OXYGEN REGULATOR
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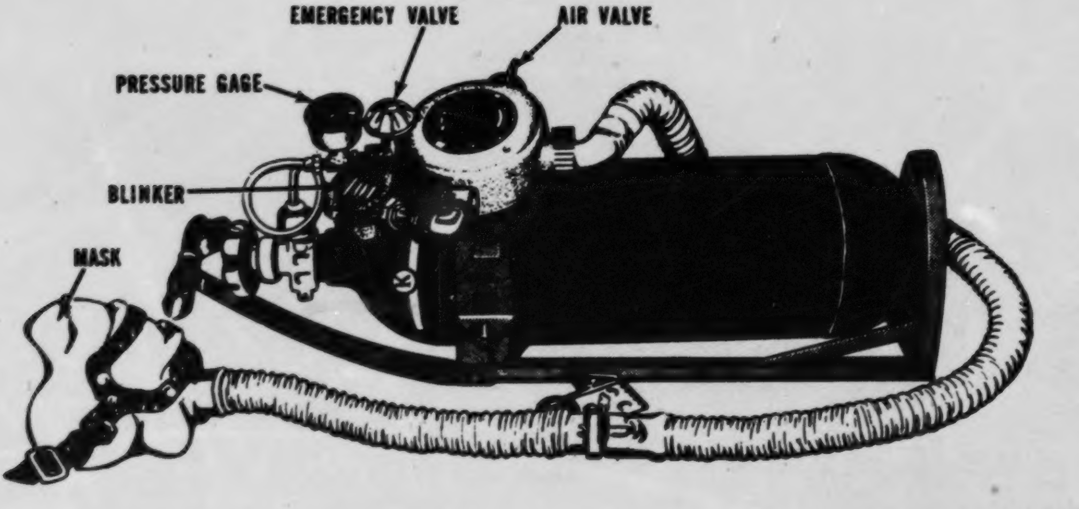
Figure 7-10.—High-pressure oxygen system.



AM.127

Figure 7-11.—Walkaround oxygen bottle (cylinder).

SURVIVAL KIT OXYGEN SYSTEMS

The survival kit oxygen system is similar to the reduced-high-pressure system discussed earlier in this chapter. The major difference is the size of the components used in the survival kit system. The survival kit system parts are miniaturized to permit their installation in the container which fits into the seat bucket of the ejection seat.

Figure 7-12 shows the survival kit system used in the F-4 aircraft. The upper half of the kit, which contains the emergency oxygen system, is illustrated in figure 7-13. Most survival kit oxygen systems are similar to the one shown in figure 7-13 except for the shape of the oxygen cylinder. The cylinder could be a standard small type similar to the one shown in figure 7-14, "U" shaped, or "coil" shape. The latter two were designed to accommodate a larger volume of oxygen for high-altitude ejection.

The coil type oxygen cylinder shown in figure 7-13 is constructed of steel tubing and is designed to hold 100 cubic inches of gaseous oxygen at 1,800 psi. The flow of oxygen is controlled and regulated by the pressure reducer manifold (fig. 7-13). The filler valve and oxygen pressure gage are attached to the manifold. The manifold is actuated automatically during ejection or manually by pulling on the emergency oxygen release ring (fig. 7-12).

The survival kit system may be serviced in the aircraft or removed from the aircraft for servicing. Low oxygen pressure in a cylinder that has not been actuated by the crewmember for use is usually an indication of a leak. In such cases the survival kit may have to be removed and forwarded to the survival equipment shop for repair.

The survival kit system consists of the kit and upper and lower personal equipment quick-disconnect blocks. The function of the kit is to provide support for the crewman during normal and emergency flight conditions. During normal flight, the system provides a seat cushion for the crewman and a routing for ventilation air, anti-g pressure, breathing oxygen, and communications. During emergency conditions and high-altitude ejection, the kit provides oxygen for breathing. Flotation and survival equipment are included in the lower half of the kit to provide support on water or in remote areas. The inspection hole on the forward end of the seat cushion provides a means for observing the emergency oxygen cylinder pressure gage. The "Lift Here" arrow indicates the location of the kit carrying handle.

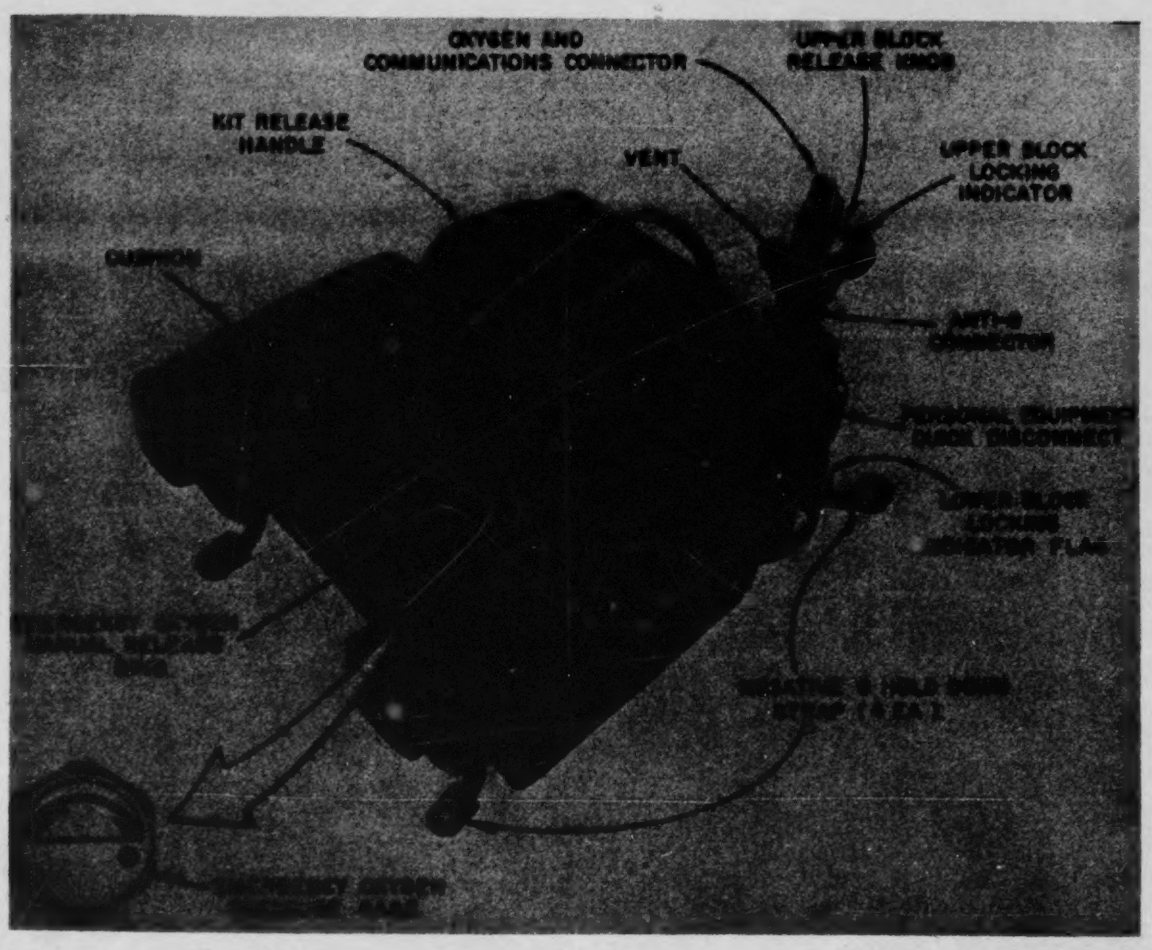

OXYGEN AND COMMUNICATIONS CONNECTOR
UPPER BLOCK RELEASE KNOB
KIT RELEASE HANDLE
VENT
UPPER BLOCK LOCKING INDICATOR
CUSHION
ANTI-G CONNECTOR
PERSONAL EQUIPMENT QUICK DISCONNECT
LOWER BLOCK LOCKING INDICATOR FLAG

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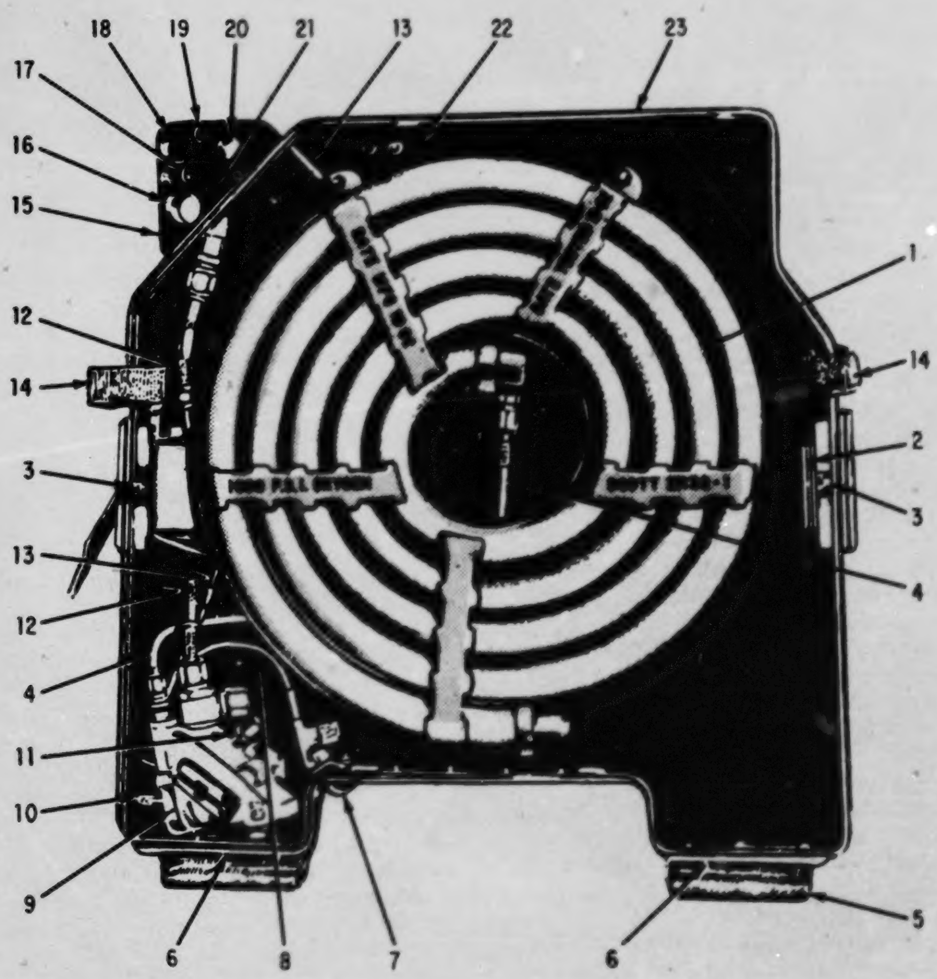
Figure 7-12.—Survival kit system (F-4).

The survival kit release handle, located on the left-rear side of the upper half, is used to open the kit. This is accomplished by depressing the locking trigger and pulling up on the handle. On some model survival kits an interlock lever must be depressed prior to moving the kit release handle during ground maintenance to prevent life raft inflation.

Survival Kit System Operation

Upon ejection from the aircraft, the survival kit emergency oxygen is tripped as the lower block of the composite disconnect separates from the intermediate block. This provides the crewman with breathing oxygen as he descends from high altitudes. If for any reason the oxygen fails to trip automatically, the crewmember must pull the emergency oxygen release ring, located on the front of the survival kit.

In over water operation, the crewmember must pull up on the kit release handle when a low altitude is reached. This action releases the bottom of the survival kit container and causes the raft to inflate. The container and raft drop



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1. Emergency O_2 cylinder.
2. Lid lock hook shim.
3. Lid lock hook.
4. O_2 high pressure line.
5. Leg support pad.
6. Lid hinge.
7. Emergency O_2 release ring.
8. O_2 actuating cable.
9. Pressure reducer manifold.
10. Toggle arm.
11. Filler valve.
12. O_2 low pressure line.
13. O_2 emergency actuating cable.
14. Drop line lanyard.
15. Intermediate block.
16. Anti-g air passage.
17. Lower block lock receptacle.
18. Communications connector.
19. Emergency O_2 actuator.
20. Vent air passage.
21. O_2 passage.
22. Container shell.
23. Mating rim.

Figure 7-13.—Survival kit container (emergency oxygen system—upper half).

and hang from a drop line lanyard secured to the container top. After entering the water and climbing aboard the life raft, the crewmember pulls in the survival equipment container and initiates appropriate search and survival procedures.

BAILOUT BOTTLES (CYLINDERS)

The bailout bottle (cylinder) is a portable oxygen system which is installed in the seat pan of parachutes used in aircraft which are not equipped with ejection seats. The H-2 Emergency Oxygen (bailout bottle) Cylinder is shown in figure 7-14. This unit consists basically of a 22.5-cubic inch cylinder, a metering orifice, a refill valve, a pressure gage, a ball handle (or "green apple"), a caution tag and pin, and a tube and connector.

The tube and connector attach to the oxygen-mask-hose connector for either the A-13A pressure-breathing mask or the A-14 demand mask. The oxygen cylinder, stored in the seat pan, is filled through the refill valve with 99.5 percent pure aviator's breathing oxygen to a pressure of 1,800 psi.

For maximum performance of this emergency-oxygen equipment, the following operational instructions should be followed:

1. The caution tag and pin must be removed from the cylinder after installation in the aircraft.
2. Before a bailout the emergency-oxygen system should not be actuated until the last possible instant before leaving the aircraft. In the case of multiplace aircraft, the aircraft crew should remain connected to the regular aircraft oxygen supply while all other preparations for leaving the aircraft are made.
3. To actuate the mechanism, a force of 20 pounds (a hard pull) in a straight-up direction must be exerted on the ball handle. When the ball is pulled, the cable does not disengage from the cylinder as a parachute ripcord does, but remains attached to the assembly.
4. The web tab on the oxygen-mask-hose connector (MC-3A) should be attached to the parachute chest buckle or other secure position on the person before takeoff. This secures the bottom end of the oxygen mask hose with the connector and prevents possible injury as a result of the hose striking the face after bailout.

To use this emergency equipment in case the regular aircraft oxygen system fails, the user should:

1. Put the emergency-oxygen equipment into operation by pulling the ball handle immediately after the malfunctioning of the regular oxygen system is noted.
2. Disconnect the mask tube connector from the aircraft breathing tube and proceed in 10 minutes or less to an altitude at which the use of oxygen is not required.

GASEOUS OXYGEN SYSTEM MAINTENANCE

The maintenance procedures discussed in this section are general in nature. Consult the applicable Maintenance Instructions Manual prior to performing any maintenance on each specific type of aircraft. Routine maintenance includes servicing of cylinders, checking the system and regulators for leaks, operationally checking the system, and troubleshooting malfunctions.

TROUBLESHOOTING

Malfunctions may become apparent during inspections, testing, or actual use of the oxygen system. The remedies for some malfunctions will be quite obvious, while others may require extensive time and effort to pinpoint the actual cause. The effectiveness of corrective action will be dependent on an accurate diagnosis of the malfunction.

Troubleshooting of the gaseous oxygen system, as with other systems, is the process of locating a malfunctioning component or unit in a system or mechanism. In order to troubleshoot intelligently, the AME must be familiar with the system and know the function of each component within the system. He can study the schematic diagrams of the system provided in the Maintenance Instructions Manual to gain a mental picture of the location of each component in relation to other components. By learning to interpret these diagrams, the AME can save time in isolating malfunctioning components. The schematic diagram does not indicate the location of components in the aircraft; however, it will provide the AME with the means to trace the oxygen flow from the cylinder through each component to the mask.

Installation diagrams provided in either the MIM or the Illustrated Parts Breakdown will assist the AME in locating the particular component in the aircraft.

The Maintenance Instructions Manuals provide a variety of troubleshooting charts which

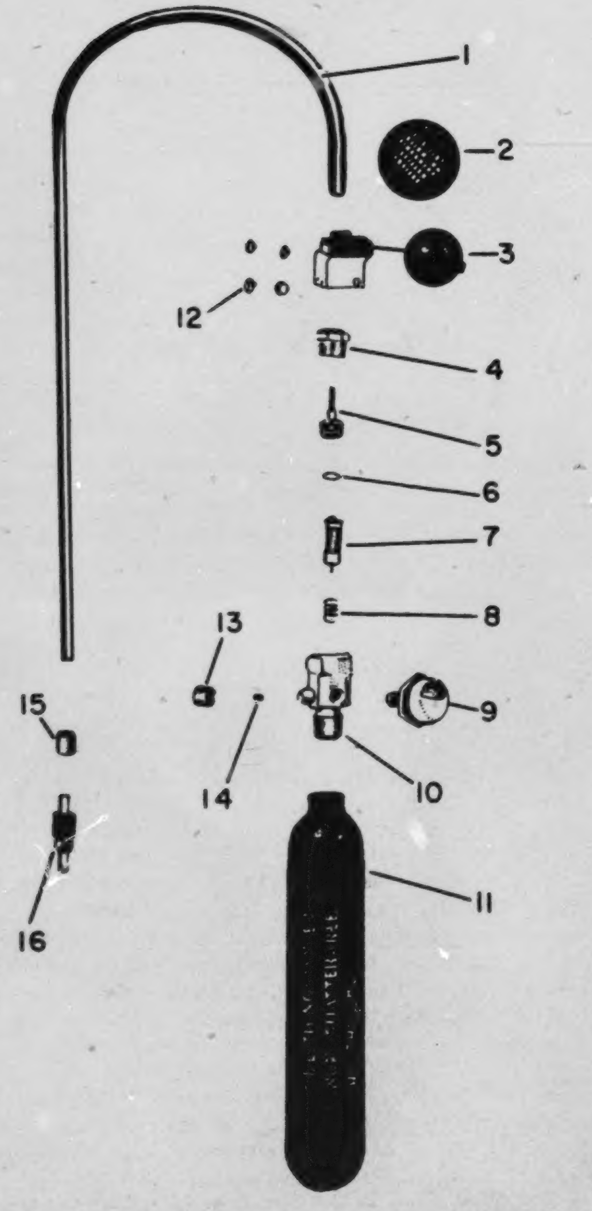

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Figure 7-14.—Type H-2 Emergency Oxygen Bottle (cylinder).

Nomenclature for figure 7-14.

1. Hose.
2. Tag assembly.
3. Ball and head assembly.
4. Bushing assembly.
5. Nipple.
6. O-ring.
7. Orifice assembly.
8. Spring.
9. Gage.
10. Body assembly.
11. Cylinder.
12. Screw and washer assembly.
13. Cap.
14. Filter.
15. Ferrule.
16. Shell and core assembly.

are intended to aid the AME in discovering the cause of malfunction and their remedy. Table 7-1 illustrates one type of chart. The discrepancy is listed in the left-hand column with the probable cause in the second and the remedy in the third. The list of probable causes is arranged in the order of probability.

Some manufacturer's troubleshooting charts or aids may include several sheets, similar to the one illustrated in table 7-2. This sheet gives a step-by-step method to correct known malfunctions. Notice how each step progresses through the system. At each step it indicates a correction procedure; however, if the system checks OK at that point, directions are given to proceed with further logical troubleshooting. In almost all cases the steps of troubleshooting are arranged to correspond with the steps of the operational checkout procedures. In any case the AME who utilizes the seven steps to follow during troubleshooting (discussed in chapter 5) will find that his troubleshooting attempts are definitely more efficient than the haphazard methods employed by some less than professional mechanics.

PURGING

When aircraft gaseous oxygen systems are opened due to replacement of parts in the system, all lines and equipment must be immediately plugged or capped to prevent entrance of foreign material. Use only clean caps or plugs to close such oxygen equipment openings. Tape, rags, paper, etc. are specifically prohibited.

If a gaseous oxygen system has been accidentally left open due to replacement of parts, that is, if all lines were not properly plugged or capped, the system must be purged. Also, if the oxygen supply was drained (completely used up) during flight and was not recharged with oxygen within 2 hours after landing the system must be purged.

Table 7-1.—Gaseous oxygen system troubleshooting.

Discrepancy	Probable cause	Remedy
Excessive leakage of system pressure.	Filler valve leaking.	Replace filler valve.
	Leak in lines.	Check tubing, fittings, and connections and repair or replace as necessary.
	Flexible hose leaking.	Replace hose.
	Regulator not shut off.	Shut off regulator.
Crewmember receives insufficient oxygen at high altitude.	Improperly functioning regulator.	Replace regulator.
	Ill-fitting mask.	Refit or replace mask.
	Mask flapper valve not operating properly.	Check mask exhaust valve.
	Flexible tubing to mask crushed or kinked.	Replace tubing as necessary.
No pressure reading at the regulator.	Defective regulator.	Replace regulator.
	Oxygen supply turned off.	Turn on cylinder hand valve if so equipped.
	System not charged.	Replenish oxygen supply.
Regulator pressure gage indications are incorrect.	Gage defective.	Replace gage.
Regulator flow indicator not functioning.	Indicator defective.	Replace regulator.

Purging is accomplished by one of the following methods:

In aircraft having the filler lines and distribution lines commonly connected to one end of the storage cylinder(s), purging is accomplished by filling the system with gaseous oxygen and then draining the system at least three times.

In aircraft having the filler lines connected on one end of the cylinder and the distribution lines connected to the opposite end, purging is accomplished as follows:

1. Connect an oxygen servicing trailer to the oxygen filler valve.
2. Open the oxygen regulator(s) supply valve, place the air dilution valve at 100% OXYGEN, and place the safety pressure valve in the ON position.
3. Set the servicing trailer regulator at 50 psi and allow oxygen to pass through the entire system for a period of at least 30 minutes.

SYSTEM LEAKAGE

Oxygen system leakage is determined by comparison of the oxygen-cylinder pressure-gage readings at the start and end of a 24-hour period. The system pressure must not have decreased below the specified limits after allowance for temperature changes has been made. Where the system pressure drop exceeds the

Table 7-2.—Oxygen system troubleshooting (P3-sheet 3).

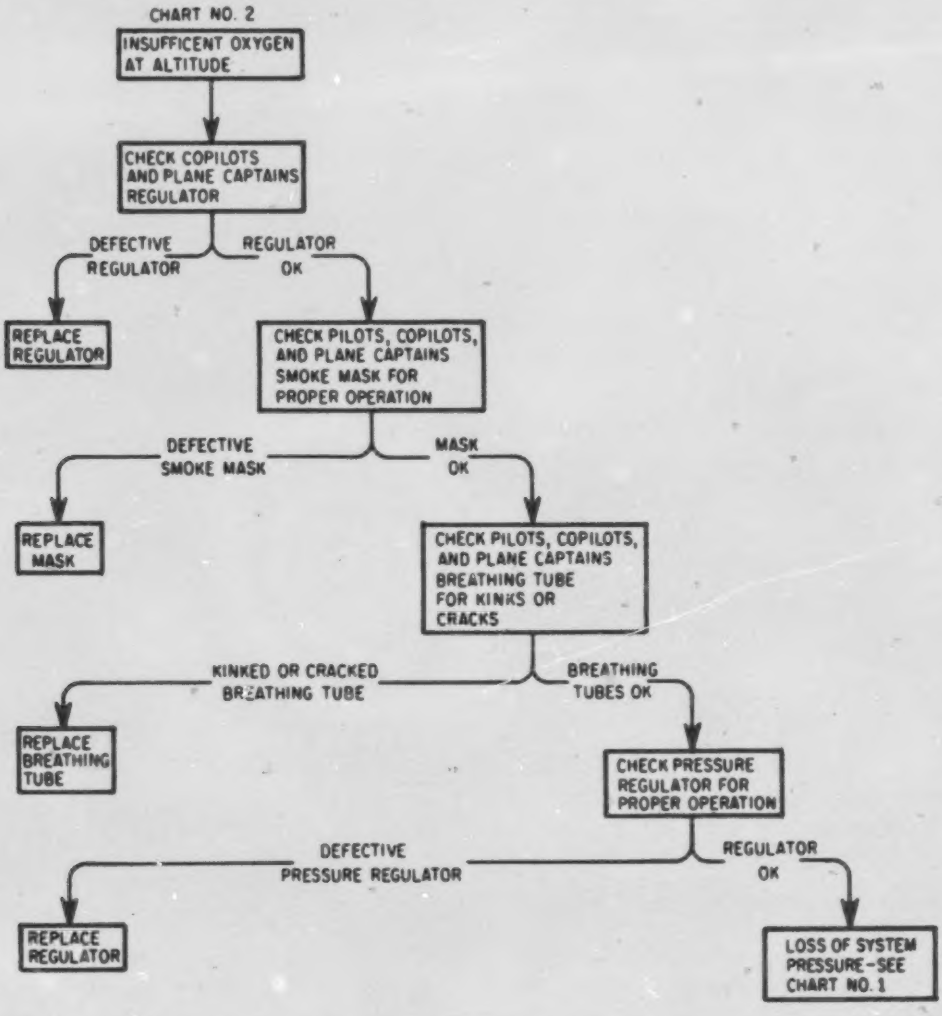
CHART NO. 2
INSUFFICENT OXYGEN AT ALTITUDE
CHECK COPILOTS AND PLANE CAPTAINS REGULATOR
DEFECTIVE REGULATOR
REGULATOR OK
REPLACE REGULATOR
CHECK PILOTS, COPILOTS, AND PLANE CAPTAINS SMOKE MASK FOR PROPER OPERATION
DEFECTIVE SMOKE MASK
MASK OK
REPLACE MASK
CHECK PILOTS, COPILOTS, AND PLANE CAPTAINS BREATHING TUBE FOR KINKS OR CRACKS
KINKED OR CRACKED BREATHING TUBE
BREATHING TUBES OK
REPLACE BREATHING TUBE
CHECK PRESSURE REGULATOR FOR PROPER OPERATION
DEFECTIVE PRESSURE REGULATOR
REGULATOR OK
REPLACE REGULATOR
LOSS OF SYSTEM PRESSURE-SEE CHART NO. 1

specific allowable amount, excessive leakage is indicated, and the particular aircraft affected should not be flown above 10,000 feet until excessive leakage is eliminated. The allowable system pressure drop for a 24-hour period for high-pressure oxygen systems using one of the following size oxygen cylinders with one oxygen regulator is as follows:

295-cubic inch cylinder	90 psi
514-cubic inch cylinder	50 psi

To determine allowable pressure drop for oxygen systems utilizing more than one cylinder of the above sizes and/or more than one oxygen regulator, the allowable pressure drop for a single cylinder/regulator installation should be divided by the number of cylinders used and multiplied by the number of regulators installed in the system.

EXAMPLE: Three 514-cubic inch oxygen cylinders; two oxygen regulators. Allowable pressure drop for system utilizing one 514-cubic inch cylinder with one oxygen regulator is 50 psi; therefore, the allowable pressure drop for a 24-hour period is

$$50 \times 2/3 = 33.3 \text{ psi}$$

Allowance should be made for temperature change between start and finish of the test period before determining the pressure drop. Such correction is approximately 3.5 psi increase for each degree (Fahrenheit) rise in temperature; and approximately 3.5 psi decrease for each degree (Fahrenheit) drop in temperature.

REGULATOR LEAKAGE

Periodically, the oxygen regulators must be checked for leakage. Outlined below is the procedure recommended in the Maintenance Instructions Manual for a typical naval aircraft. For some installations the procedure may vary slightly, depending upon the type of regulator installed in the aircraft.

1. Charge the oxygen system to a pressure of 1,800 psi.
2. Turn on full oxygen supply—gage on the regulator should read 1,800 psi.
3. Operate safety pressure lever and note that there is a flow of oxygen through the regulator. If no flow is obtained, replace the regulator.
4. Place diluter control in 100% OXYGEN position.
5. Inhale through the regulator to determine whether the demand valve and flow indicator are functioning. If no oxygen flow is obtained, or if the indicator does not operate, replace the regulator.
6. With supply pressure still ON, turn off regulator valve. Pressure trapped by the valve as indicated by the pressure gage must not fall more than 100 psi in 2 minutes. If pressure drop is more than 100 psi in 2 minutes, replace the regulator.
7. With the supply pressure still ON, attach the quick-disconnect male portion of the breathing tube to the breathing tube coupling. Place a continuous film of leak test solution (MIL-L-25567A) across the open end of the breathing tube. Hold the tube steady. Formation of a bubble expanding more than 1/16 inch in 3 seconds indicates internal leakage within the regulator. Repeat this test three or four times to make sure that excessive forward motion of the leak test solution film is not caused by temperature differences between inside and outside of regulator. A defective regulator must be replaced.

CAUTION: Leak test should be made with a leak test solution which conforms to Specification MIL-L-25567A. After the test, all solution must be removed with clean water and tested areas dried with a clean cloth. Do not permit the solution to run into the regulator.

PREFLIGHT INSPECTION OF REGULATORS

Before each flight which will require the use of oxygen, regulators must be given a functional test. Outlined below is a typical procedure:

1. Turn the oxygen supply shutoff valve to ON position.
2. Check oxygen system pressure. If the system is fully charged, the gage should read 1,800 ± 50 psi at 70° F.
3. Test the breathing tube, couplings, regulator diaphragm, and diluter check valve for leakage by grasping the breathing tube and fully stretching it. While the tube is fully extended, place the thumb over the open end of the disconnect and permit the breathing tube to contract. Observe the blinker plate of the oxygen flow indicator as back pressure operates the blinker. If after 5 seconds the blinker plate has not returned to its normal position, all portions of the system from the regulator demand valve to the breathing tube disconnect are acceptable as to leakage. If the flow indicator face closes within 5 seconds, leakage is excessive. If leakage exists, check the couplings, outlet elbow, and breathing tube clamps for tightness.
4. Fully engage the mating portions of the coupling, connecting the mask to the personnel gear adapter. The force required to disconnect the coupling should not be less than 10 pounds.
5. Check the operation of the regulator by breathing several times with the air valve in both the NORMAL and 100% OXYGEN positions. Check the operation of the safety pressure valve for a positive flow of oxygen with the lever in the ON position. Observe the oxygen flow indicator to confirm the positive flow of oxygen to the mask.

INSTALLATION OF REGULATORS

The following is a typical regulator installation procedure. Removal of the regulator is performed in the reverse order. NOTE: When removing or installing oxygen regulators, refer to the appropriate volume of the applicable Maintenance Instructions Manual for detailed instructions concerning the particular aircraft.

1. Remove the dust plugs from the inlet fitting and outlet elbow.
2. Apply oxygen system antiseize and sealing compound to the male threads. Do not allow the compound to run into the open end of the nipple.
3. Set the regulator in position on the mounting bracket and attach the oxygen supply line.
4. Remove the plug from the flow indicator connection.
5. Apply thread lubricant (as above) to the flow indicator line nipple, and insert the nipple into the regulator boss. Tighten carefully; do not exceed a torque of 50 inch-pounds.
6. Attach the regulator to the mounting bracket.
7. Attach mask-to-regulator tubing to the oxygen-air outlet with hose clamp.
8. Connect oxygen cylinder(s) to supply lines.
9. Check the regulator for proper operation.
10. Check all fittings for leakage using leak test solution.

INSTALLATION AND CHECKOUT OF SYSTEM COMPONENTS

A thorough knowledge of the following general procedures for installation and checkout of oxygen system components should expedite the handling of oxygen system components and help prevent serious accidents or possible death.

1. Insure that only tubing assemblies which have been tested, cleaned, capped, and properly identified are used in oxygen systems.
2. Use only the type of fittings specified for the particular oxygen system. Never use fittings with pitted or otherwise disfigured cones, or imperfect threads.
3. Use only the specified valves, reducers, and regulators. Always refer to the applicable Illustrated Parts Breakdown for the proper parts.
4. Because of the explosive nature of an oxygen/grease mixture, none of the standard thread compounds can be used on oxygen fittings. Acceptable compounds are limited to those approved under MIL-T-5542C and antiseize tape conforming to Military Specification MIL-T-27730A and are used only to prevent thread seizure. These compounds should be applied sparingly and carefully to male pipe threads only. Do not dip the fitting into the thread compound. Thread compound must not be used on flared-tube fitting straight threads. Never permit the compound to enter a fitting. Naturally, extreme care should be exercised to prevent contamination of the thread compound itself with oil or grease. Antiseize tape is applied to oxygen tapered pipe thread fittings as previously covered in chapter 3.
5. Be certain that bonding surfaces are free of primer and residue of any sort. Electrical bonding prevents the buildup of high potential static charges that can be generated by the friction of flowing gas. Arcing erodes metal, and can actually perforate thin gage materials, such as tubing walls.
6. When installing tubing, the fitting should align without the use of undue force.
7. The torque values specified for the particular oxygen system should be strictly adhered to when tightening the fittings. Never overtorque a fitting to effect a seal or establish a proper electrical bond; loosen the fitting and retorque it several times, if necessary, until the seal or bond has been established.
8. If a section of an oxygen line is left open or disconnected during installation, the open fittings should be covered with suitable caps. While making connections, insure that lint, dust, chips, or other foreign material is not allowed to enter the oxygen system.
9. Upon completion of the installation of tubing or components, the system should be pressure checked for leaks. Each newly installed connection should be checked (with the system pressurized) using a leak test solution. Leak test compound conforming to Specification MIL-L-25567A is approved for this purpose. After a connection has been leak tested, the leak test solution should be removed from the tubing completely by a thorough washing with clean water. After rising, the tubing should be dried.
10. The completed system should be purged prior to releasing the aircraft for flight.
11. Always make a final operational check of the finished system by checking the oxygen flow when the regulator is turned on.

SERVICING TRAILERS

There are several different models of gaseous oxygen servicing trailers currently in use by naval activities. They are all similar in operation; therefore, only one, the type NO-2, manufactured by Aeroil Products, Incorporated, is described here. The general appearance of the trailer is illustrated in figure 7-15.

Equipment provided on the trailer includes two pressure regulators, an upper and lower manifold, six manifold control valves with pressure gages, a recharge valve, four shutoff valves, a servicing hose fitted with a line (service) valve and capable of accommodating either a high-pressure or a low-pressure charging adapter, a drier assembly, and six cylinders and connecting flexible hoses. The function of each of these components is described in the following paragraphs.

COMPONENTS

Pressure Regulators

The pressure regulator controls the charging pressure when the trailer is being used to service aircraft oxygen systems. Only one pressure regulator is used during operation. The spare is provided to insure uninterrupted operation should one fail.

When the shutoff valves on the inlet and outlet sides of the regulator are open, the pressure regulator is ready for use. By turning the regulator control handle clockwise, the pressure (as read on the gage attached to the regulator) will increase. Turning the control handle counterclockwise decreases pressure.

Manifold Control Valves

The six manifold control valves serve to shut off the flow of oxygen from the cylinders to the system being charged. These valves are lever type valves. The manifold control valves should not be used for long time storage. Always use the handwheel type valves located on the cylinders.

Shutoff Valves

There are four shutoff valves, one on the inlet side of each pressure regulator and one on the outlet side of each regulator. These shutoff valves control the flow of oxygen from the upper manifold to the lower manifold, via the regulator.

Drier Assembly

The drier assembly is a reservoir containing a chemical drying agent through which the oxygen must pass before going through the servicing hose. This chemical drier is provided to remove any moisture in the oxygen supply. The oxygen flows into the bottom of the drier, passes up through the drying agent, and out through the servicing hose.

Recharge Valve

The recharge valve is provided as a means of recharging the trailer cylinders directly through the upper manifold without the necessity of removing the cylinders. When not in use, the valve adapter should be fitted with a dust cap.

Servicing Hose and Line Valve

The servicing hose is a high-pressure, nonkinking, metallic flexible hose. The line servicing valve is attached to the servicing hose and is used to control the flow of oxygen to the system being charged.

OPERATION

The six supply cylinders are connected by means of flexible hoses to their respective control valves. (See fig. 7-16.) The six control valves are attached to the upper manifold. A pressure gage is screwed into each control valve at a point below the seat. This allows each cylinder pressure to be easily read.

The oxygen flows from the upper manifold through either of two pressure regulators via two shutoff valves.

The oxygen is collected in the lower manifold where a gage registers the pressure of the delivery side of the system. The lower manifold is connected by flexible hose to a drier which filters and dries the oxygen. The servicing hose connects directly to the drier and has a line servicing valve on the terminal end. The line servicing valve is fitted with a standard oxygen cylinder connection.

NOTE: Servicing of gaseous oxygen systems is discussed in chapter 10.

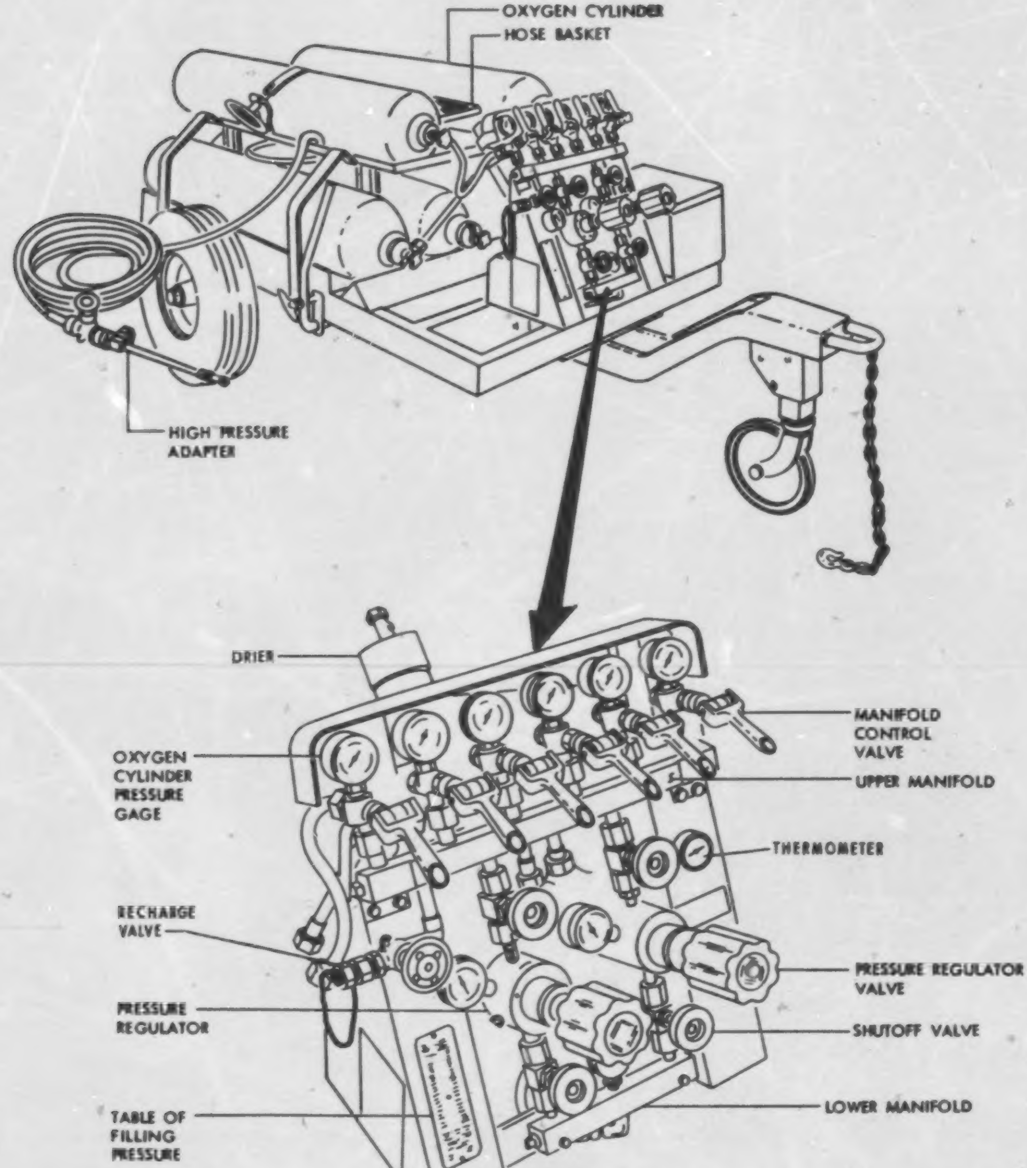
OXYGEN CYLINDER
HOSE BASKET
HIGH PRESSURE ADAPTER
DRIER
MANIFOLD CONTROL VALVE
OXYGEN CYLINDER PRESSURE GAGE
UPPER MANIFOLD
THERMOMETER
RECHARGE VALVE
PRESSURE REGULATOR VALVE
PRESSURE REGULATOR
SHUTOFF VALVE
LOWER MANIFOLD
TABLE OF FILLING PRESSURE

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Figure 7-15.—Type NO-2 gaseous oxygen servicing trailer.

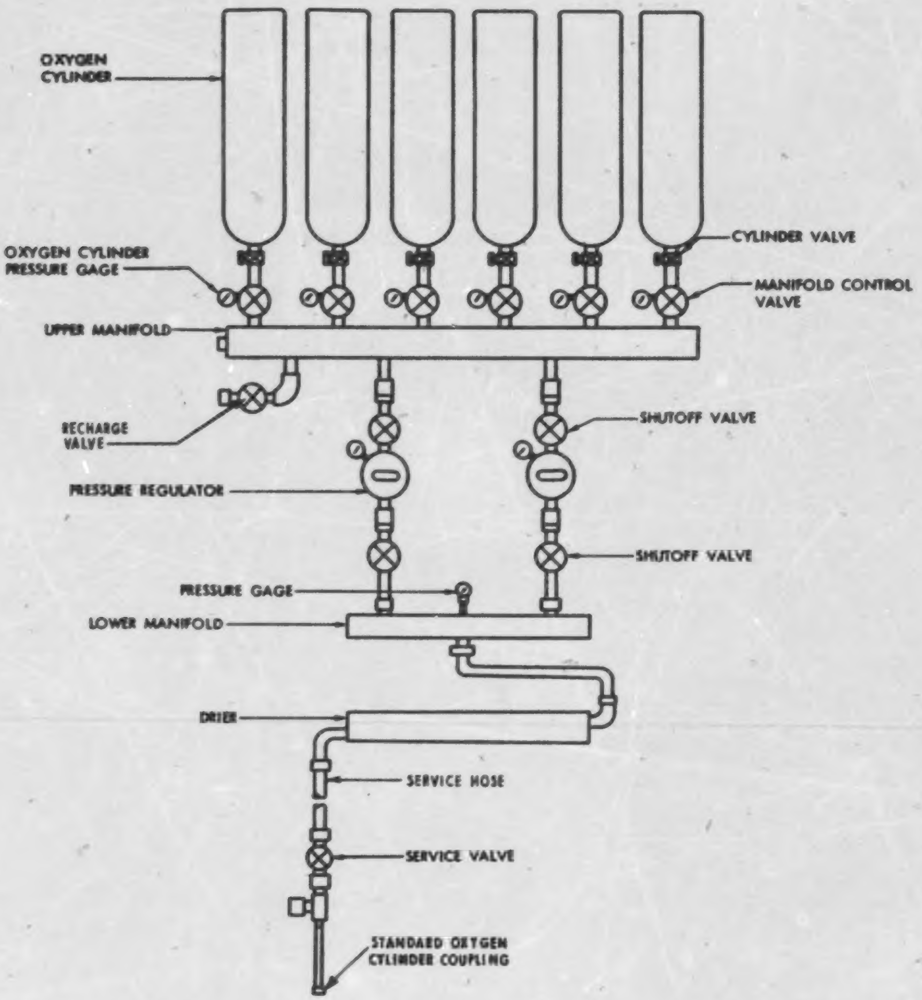
OXYGEN CYLINDER
CYLINDER VALVE
OXYGEN CYLINDER PRESSURE GAGE
MANIFOLD CONTROL VALVE
UPPER MANIFOLD
RECHARGE VALVE
SHUTOFF VALVE
PRESSURE REGULATOR
SHUTOFF VALVE
PRESSURE GAGE
LOWER MANIFOLD
DRIER
SERVICE HOSE
SERVICE VALVE
STANDARD OXYGEN CYLINDER COUPLING

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Figure 7-16.—Type NO-2 gaseous oxygen servicing trailer (schematic).

MAINTENANCE

The AME is responsible for Organizational and Intermediate level maintenance of gaseous oxygen servicing trailers. Maintenance includes loading of cylinders, miscellaneous parts repair and/or replacement, and preoperational and periodic inspections. Replacement of the drying agent is covered as a part of the periodic inspection requirements but may require more frequent attention than the other inspection elements.

Loading Cylinders

The servicing trailer is capable of having its cylinders recharged without removal. However, most operating activities replace the empty cylinders with full cylinders.

NOTE: Never completely expend the supply of oxygen from a cylinder. Always leave a residual pressure in excess of 50 psi.

REMOVAL OF EMPTY CYLINDERS.—When the trailer has been in use and cylinder pressure is low, the cylinders are removed as described below.

1. Close all lever valves on the manifold prior to removing any cylinders.
2. Close the cylinder shutoff valves.
3. Disconnect the flexible hose which connects the cylinder to the manifold.
4. Loosen the clamping arrangement which holds the cylinders to the trailer. (See fig. 7-15.)
5. Install the cylinder safety caps.
6. Remove the empty cylinders.

CAUTION: Do not attempt to remove empty cylinders while charging.

INSTALLATION OF FULL CYLINDERS.—The trailer should be loaded with cylinders while fastened to a towing vehicle. If a towing vehicle is not available, the rear stand should be let down and the hand brakes applied so the weight of the cylinders will not cause the trailer to tilt backwards. The retractable swivel wheel should be down if the trailer is not hooked to a towing vehicle. (When the trailer is hooked to the towing vehicle, the swivel wheel should be retracted.) Cylinders should be loaded from the rear and should be handled with safety caps in place. Standing cylinders should be brought to within 4 feet of the rear end of the trailer. If the cylinders are lying down, the safety cap end of the cylinder should be just below the rear of the trailer. The safety cap end of the cylinder should be lifted or lowered and placed in the appropriate channel. The bottom of the cylinder should be raised and the cylinder worked into place.

Insure that the cylinder is in its forwardmost position and firmly seated against the forward cylinder stop. Remove the cylinder safety cap. Position the cylinder so that the cylinder valve outlet may be easily connected to the flexible hose without causing undue strain on the hose. Prior to connecting the hose to the cylinder, crack (open) the cylinder valve slightly to blow any foreign matter from the outlet of the valve; then close the valve. Connect the flexible hose nut to the proper cylinder valve. As soon as the cylinders are in place and the hoses connected, the clamping arrangement should be tightened. The bottom four cylinders are clamped in pairs by a wheel, and the top cylinders are tightened by a single strap for each one.

After tightening the coupling nuts on the hoses, the hoses should be free of torsional (twisting) strain. This strain can be prevented by gripping the hose with one hand and twisting slightly in a clockwise direction while tightening the coupling nut. When the nut becomes tight, the hose will twist (counterclockwise) slightly as it seats, and will stop approximately at its neutral position.

CAUTION: To eliminate the danger of an explosion, do not interchange parts between oxygen servicing equipment and air/nitrogen equipment. To prevent the possibility of interchanging similar parts between oxygen and air/nitrogen equipment, all critical items for oxygen equipment, (valves, regulators, and hoses) are manufactured with left-hand threads.

After replacing the empty cylinders, the cylinder valves on the full cylinders should not be opened until the trailer is positioned for servicing an aircraft.

Replacement of Drying Agent

The chemical drier should be inspected after every twelve cylinders are used, and the chemical agent should be replaced at the first sign of change in the indicator. The drying agent is white in color with an indicating agent, blue in color. The indicating agent is applied on top of the drying agent. When moisture is present, the indicating agent will change color from blue to pink. Inspection is easily made by removing the servicing hose and unscrewing the top cap of the drier container.

CAUTION: Relieve all pressure prior to replacement of chemical agent.

The drying agent is removed by removing the hose connecting the lower cap and the lower manifold and unscrewing the drier lower cap. All traces of the contaminated agent should be removed and the lower cap replaced and the lower manifold hose connected. The drying agent should be quickly placed in the drier so that it does not pick up moisture from the air. Care should be given to the replacement of the indicating agent, and the top cap should be screwed in place immediately after observing the condition of the indicator so that the moisture of humid air does not cause the indicator to change color.

The caps on the drier should be screwed down until they bottom. The caps should only be removed and replaced by hand. It is not necessary to tighten the caps extremely tight. The caps are sealed with O-ring packings which usually give good service. However, if leakage occurs, the O-ring should be replaced. Refer to the applicable Operation and Service Instructions Manual (which includes the Illustrated Parts Breakdown) for the part number of the O-ring.

NOTE: All maintenance on the gaseous oxygen servicing trailer should be performed in accordance with the instructions contained in the applicable Operation and Service Instructions Manual or set of Maintenance Requirements Cards.

Daily/Preoperational Inspections

Maintenance requirements for the gaseous oxygen servicing trailer are provided in daily or preoperational and periodic Maintenance Requirements Cards. These cards provide the minimum requirements necessary to maintain the equipment and insure that no item is overlooked. They do not contain instructions for repair, adjustment, or means of rectifying defective conditions. The cards are arranged in a work area sequence similar to aircraft Maintenance Requirements Cards so that the inspections can be held in an efficient manner.

The daily requirements should be accomplished prior to the first use of the equipment for that day. It may be necessary to repeat some of the requirements prior to each use of the equipment. The daily inspection for the Type NO 2 gaseous oxygen trailer is conducted in the following manner:

1. Handbrake and connecting rods for distortion, security, and effective operation.
2. Main wheels for security; tires for cuts and specified pressure of 70 psi.
3. Retractable wheels for proper swivel action, security, and retracting, tires for cuts and specified pressure of 30 psi if applicable.
4. Draw bar for cracks and security; safety chains for security.
5. Toolbox for security and proper tool content.
6. Cylinder racks and manifold stand for security.
7. Assembly for evidence of leakage under pressure.

WARNING: Do not use oil, grease, or other readily oxidizable material with oxygen equipment.

CAUTION: Do not interchange parts between oxygen and air/nitrogen servicing equipment because of danger of explosion.

8. Gages for cleanliness, fogged, and/or cracked glass.
9. Valves for rotation without binding.
10. Regulators for proper operation.
11. Hose for chafing, kinks, and deterioration; service fittings for cleanliness and distortion.
12. Safety head for presence of proper frangible disc.

NOTE: Relieve all pressure after inspection.

13. Oxygen storage cylinders for security.
14. Valves for cleanliness, rotation without binding, and evidence of leakage.
15. Storage cylinders properly recharged.

NOTE: Performance of the inspection is recorded on the Ground Support Equipment-Daily Record, OpNav Form 4790/52. Manhours expended performing the inspection are accounted for on the Support Action Form (SAF).

CHAPTER 8

LIQUID OXYGEN SYSTEMS

The majority of naval aircraft are equipped with liquid oxygen (LOX) systems. Liquid oxygen systems are not particularly difficult to service, nor are they unusually dangerous, provided all the necessary safety precautions are observed. Oxygen in the liquid form is generally less dangerous than gaseous oxygen, which is stored at a high pressure. However, because of its extremely low temperature, expansion of gasification, and its property of supporting combustion, safety precautions must be strictly observed.

SAFETY PRECAUTIONS

As already mentioned, the main dangers of liquid oxygen are the extremely low temperature of the liquid, its expansion ratio, and the supporting of violent combustion. The liquid is nontoxic, but will freeze (burn) the skin severely upon contact.

Extreme caution should be taken not to touch other implements containing liquid oxygen, unless gloves are worn. Without gloves, the skin would immediately stick to the metal surface.

Personnel that could be exposed to accidental spillage of liquid oxygen must wear a face shield, coveralls, gloves, and oxygen safety shoes to prevent skin and vision damage. Gloves, low cut shoes, trousers with cuffs, and other improper clothing which can form pockets capable of holding a quantity of LOX in contact with the skin for a period of time long enough to cause freezing present a real hazard. All personnel handling LOX must be appropriately attired.

A greater danger than freezing is the combustion supporting potential of oxygen. When liquid oxygen is used, it is possible to build up high concentrations of oxygen quickly. Many materials such as cloth, wood, grease, oil, paint, or tar will burn violently when saturated with oxygen, provided an ignition source is supplied. A static electric discharge or spark can serve as an igniter. Once an oxygen fire is started it is virtually impossible to extinguish it until the oxygen supply is cut off.

An added danger exists if a combustible material is saturated with oxygen at low temperatures. Many materials, especially hydrocarbons, tar, etc., will burn with explosive violence when so saturated and then subjected to very mild shock or impact.

Extreme care must be taken not to splash or spill liquid oxygen onto clothing. Mixed with cloth, an ideal and deadly situation for a fire exists—a fire that cannot be put out.

Liquid oxygen by itself will not burn, but mixing with the smallest amount of nearly any material will cause the liquid to boil and splash violently, and combustion is possible. If splashed out of a container, it will split into many parts upon contact with the ground. It must be poured slowly from one container to another to avoid excessive splashing and to allow the receptacle to cool sufficiently without thermal breakage.

Never seal or cap the vent port of a liquid oxygen system, located in the lower section of the oxygen compartment and protruding through the aircraft skin. Liquid oxygen at atmospheric pressure will generate up to 12,000 pounds of pressure if allowed to evaporate in a sealed container or system which has no relief provisions. Liquid oxygen evaporates and expands into gaseous oxygen at a ratio of approximately 862 to 1 by volume. In other words, 1 cubic foot of liquid oxygen represents approximately 862 cubic feet of gaseous oxygen at the same pressure.

Access to oxygen supply/storage areas should be limited only to personnel familiar with proper handling procedures. The area should be adequately ventilated and free of any materials that could present a fire hazard.

All pressure type containers, plumbing, and pressure relief devices should conform to the applicable Maintenance Manual and be kept in good repair. The vents on liquid oxygen containers are designed to have a sufficient flow capacity to carry away any oxygen that may boil off in case of accidental loss of insulation. DO NOT cap such vents or cause the opening to be restricted in any way.

The pressure relief assembly in LOX system storage vessels consists of a reseatable relief valve and a rupture disc in parallel. The assembly is designed so that the relief valve relieves first, with the rupture disc acting as a safety backup in the event the relief valve malfunctions or its relieving capacity is exceeded.

LOX converters and servicing trailers should be stowed or parked so that they are protected from excessive heat and the direct rays of sunlight as much as is practical. All LOX containers should be segregated from containers of other gases or liquids and all flammable materials.

Lubricants applied to wheel bearings and chassis of the servicing equipment must be in strict conformance to the applicable Maintenance Requirements Cards and/or Maintenance Instructions Manual. Hydrocarbons such as oil and grease in the oxygen area of the servicing trailer could result in serious injury, death, and expensive property damage.

Smoking, open flames, or sparks should not be permitted in any liquid oxygen handling area. When transferring LOX provide adequate ventilation to prevent the formation of an oxygen rich atmosphere.

LOX spillage on floors or deck areas should be avoided. In case of accidental spillage, the area should be adequately ventilated. Intentional drainage of LOX from a system or container must be caught in a clean drain can and allowed to evaporate in a suitable open area that would not present a hazard.

In the event that liquid oxygen is spilled on clothing, the clothing should be separated from skin contact immediately and thoroughly aired to allow dilution of the oxygen concentration. When an uninsulated container of LOX is touched or when there is any reason to suspect some part of the body has been frozen or chilled, the area should be thoroughly washed or immersed in clean water which is slightly above body temperature (approximately 104° F to 113° F). The exposed area should then be loosely wrapped with clean, dry dressing and medical aid sought immediately.

When servicing and maintaining LOX systems, the AME will be required to transfer LOX from storage tanks to servicing trailers, servicing trailers to aircraft converters, and occasionally from the converter to a drain pan. He will also be required to remove and install converters and other components of LOX systems. All servicing and maintenance of LOX systems must be done in accordance with the instructions contained in the applicable aircraft Maintenance Instructions Manual. All safety precautions concerning the handling of LOX must be adhered to.

When a completely empty system is being serviced, the liquid oxygen should be added slowly to cool the system equipment down to the storage temperature (-297° F). The equipment could otherwise be damaged by thermal shock or excessive rapid pressure buildup.

Additional gaseous and liquid oxygen safety precautions and handling procedures are provided in the following publications:

OpNav Instruction 4790.2 (Series).

NavMat P-5100, Safety Precautions for Shore Activities.

NavAir 03-50-1, Oxygen Equipment, Technical Manual.

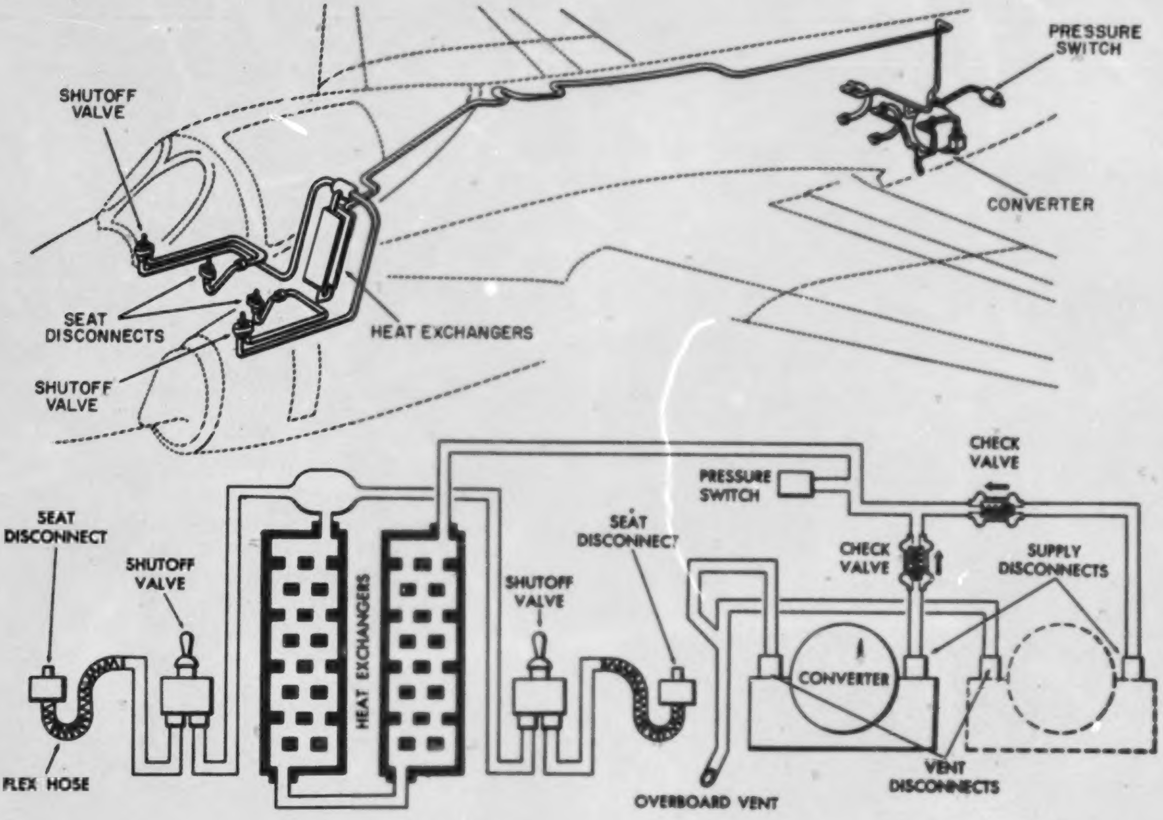
All personnel handling oxygen and maintaining gaseous or liquid oxygen systems should be thoroughly familiar with all the precautions and procedures listed in the latest revisions to these manuals as well as the specific precautions provided in the applicable aircraft Maintenance Instructions Manual and those pertaining to the type of equipment being utilized to service such systems.

LIQUID OXYGEN SYSTEM COMPONENTS

Aircraft liquid oxygen systems are similar to gaseous oxygen systems except that the several cylinders of gaseous oxygen are replaced by one or more liquid oxygen containers known as converters. The use of more than one converter provides for an adequate supply of oxygen on long range flights or where there is more than one crewmember using the oxygen system. In addition to the converter(s), most LOX systems contain a heat exchanger, shutoff valves, and quantity indicating units. Figure 8-1 shows both the installation and schematic diagram of a liquid oxygen system.

AIRCRAFT CONVERTERS

The aircraft liquid oxygen converter is a portable double-walled, vacuum insulated vessel


PRESSURE SWITCH
SHUTOFF VALVE
CONVERTER
SEAT DISCONNECTS
HEAT EXCHANGERS
SHUTOFF VALVE
CHECK VALVE
PRESSURE SWITCH
SEAT DISCONNECT
SEAT DISCONNECT
CHECK VALVE
SUPPLY DISCONNECTS
SHUTOFF VALVE
SHUTOFF VALVE
HEAT EXCHANGERS
CONVERTER
FLEX HOSE
VENT DISCONNECTS
OVERBOARD VENT

AM.132

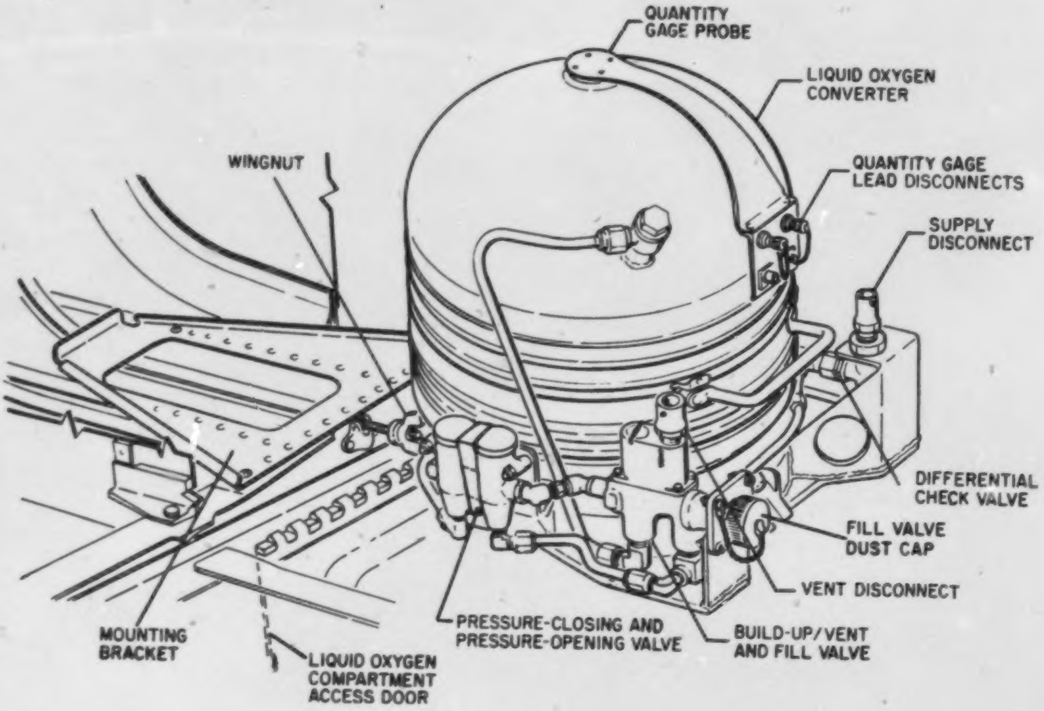
Figure 8-1.—Liquid oxygen system.

used for the storage of liquid oxygen prior to the liquid-to-gas conversion. The components necessary for conversion and control of the liquid oxygen are included as part of the converter. The converter is insulated by means of a high vacuum between the double walls. Most LOX converters are similar to the one shown in figure 8-2.

Converters are made in various sizes, the size being determined by the capacity of the converter in liters. NOTE: 1 liter equals 1.0567 quarts. The most common sizes are the 5- and 10-liter capacity. The size used depends on the number of crewmen, mission duration capability, and oxygen regulation equipment used.

The liquid oxygen converter is usually located in a space which is separated from the crew's compartment. To facilitate servicing, the oxygen compartment is usually found in an area which is easily accessible from the ground. Most aircraft are designed so that the converter may be easily removed for filling at a remotely located filling station.

All the components necessary for the storage, conversion, and control of liquid oxygen are assembled as a unit. The unit is commonly referred to as the converter. Included in the assembly are the container and the following components: filler valve (usually a combination fill, vent, and buildup valve), pressure control valve, check valve, relief valve, and two quick disconnect couplings. Two electrical receptacles for the quantity indicating system and a carrying handle are provided on the container.


QUANTITY GAGE PROBE
LIQUID OXYGEN CONVERTER
WINGNUT
QUANTITY GAGE LEAD DISCONNECTS
SUPPLY DISCONNECT
DIFFERENTIAL CHECK VALVE
FILL VALVE DUST CAP
VENT DISCONNECT
MOUNTING BRACKET
PRESSURE-CLOSING AND PRESSURE-OPENING VALVE
BUILD-UP/VENT AND FILL VALVE
LIQUID OXYGEN COMPARTMENT ACCESS DOOR

AM.133

Figure 8-2.—Liquid oxygen converter.

Container

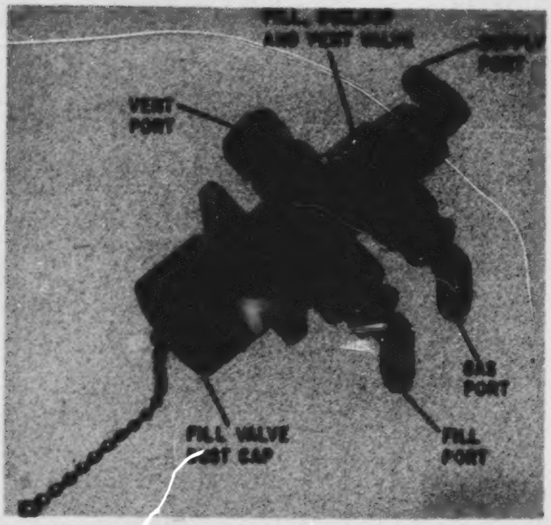
The container consists of an inner and outer shell of stainless steel, separated by a vacuum. A blowout disc in the outer shell of the container minimizes danger to personnel if excessive pressure builds up as a result of liquid oxygen leakage. Liquid oxygen leaking from the inner shell into the vacuum area expands at a ratio of 1 to 862. The excessive pressure on the outer shell will burst the blowout disc.

Filler Valves

The filler valve used in most liquid oxygen systems is a combination filler, vent, and buildup valve. A typical unit is shown in figure 8-3. The filler portion of the valve is essentially a spring-loaded check valve, designed along with the servicing equipment to form a liquid-tight seal during the filling operation, and forming a gas-tight seal when the servicing hose is removed. A removable cap keeps out dirt and dust.

When the container is being filled, the filler valve is depressed, and the liquid oxygen is routed through the fill port to the container. When the container is full, the liquid oxygen is routed back through the gas port and out the overboard vent port. When the filler valve is in the normal position (cap installed), the fill port and the overboard vent port will be closed. This will allow the gaseous oxygen boiloff (from the top of the container) to be routed through the gas port and to the oxygen system (vent and buildup condition). The valve is spring loaded to the vent-and-buildup condition. Teflon O-rings and seals are used to prevent leakage of the oxygen.

On some older aircraft, the filler valve is not the combination filler, vent, and buildup type. On such installations, two separate valves, a filler valve and a buildup/vent valve are



AM.134
Figure 8-3.—Fill, vent, and buildup valve.

incorporated. The buildup/vent valve is a manually-operated, two-position valve. The valve may be placed in either the BUILDUP or VENT position by moving the valve handle through an arc of approximately 100 degrees. In filling this type of system, the valve must be placed in the VENT position. After filling, the valve must be returned to the BUILDUP position. When this type installation is used, the handle which places the converter in the fill (VENT) condition is designed and installed in such a manner that it is impossible to close the servicing access door before the handle is returned to the BUILDUP position.

Pressure Control Valves

The pressure control valve used in most converters is a combination pressure control valve which consists of two valves internally connected in a single housing. These two valves, the pressure opening and pressure closing, are both controlled by spring-loaded bellows which are vented to the atmosphere. The pressure closing valve is spring loaded to the open position, and the pressure opening valve is spring loaded to the closed position.

The pressure closing valve maintains operating pressure within the converter by closing at a predetermined pressure level to terminate the buildup sequence of the converter operation. When there is no demand for oxygen, normal heat exchange causes a gradual rise of pressure in the converter until, at a pressure slightly higher than the operating pressure, the pressure opening valve opens and allows gaseous oxygen to be admitted into the supply line. If, on the other hand, demand is made before buildup is completed, liquid oxygen is drawn through a differential check valve and is transformed into gaseous oxygen during passage through the supply lines. (Refer to view A of figure 8-7 in the section entitled "Fill Sequence" later in the chapter.) The differential check valve opens when a pressure differential of 5 psi develops between the converter and the supply line. Operation of the pressure opening and pressure closing valve is amplified later in this chapter.

Relief Valves

A relief valve in the converter provides for relief of excess system pressure. The valve is set to relieve at a given pressure and to reseat at a given pressure. The relief valve in most LOX systems is set to open at 110 psi.

The valve is spring loaded to the closed position. The relief valve provides for pressure relief of the container when removed from the oxygen system and protects the entire oxygen system when installed and connected in the aircraft.

Because of heat entering the system, approximately 1 liter of liquid oxygen will be lost overboard through this valve during a 24-hour period when the system is not in use.

Quick-Disconnect Couplings

Quick-disconnect couplings are provided for the rapid and positive coupling of the oxygen lines. The fixed (male) half of the coupling is mounted on the container (fig. 8-2) and the disconnect (female) half is attached to the flexible oxygen sypply and vent lines.

The coupling for the supply line contains a spring-loaded check valve in each half. These check valves close automatically when the coupling halves are disengaged. The vent coupling has no check valves; however, it forms a positive seal for the vent line so that excessive system pressures will be vented overboard.

HEAT EXCHANGERS

The purpose of the heat exchanger is to raise the temperature of the evaporated liquid oxygen in order to insure that the pilot will suffer no ill effects from consuming oxygen at extremely low temperatures.

The heat exchangers of the liquid oxygen system illustrated in figure 8-1 consist of two identical aluminum alloy honeycomb structures interconnected and mounted in the cockpit area. They are flat and rectangular in appearance and made of two sheets of metal embossed and sandwiched together in such a manner as to provide a series of minute interior passages.

When gaseous oxygen flows into the cockpit through the supply line from the converter it is piped directly into the top of the first (rear) heat exchanger and out the bottom and into the bottom of the second (front) heat exchanger. The warmed oxygen then passes out of the top of the second heat exchanger and into a plenum.

The plenum is a spherical chamber which acts as a damper to prevent momentary pressure drops due to both occupants demanding oxygen at the same time. Without the plenum the low level (pressure) oxygen warning system would be intermittently activated whenever a dual demand was placed on the system.

The warmed gaseous oxygen flows from the plenum to the shutoff valves and to the flight crew's or the seat mounted regulators.

COCKPIT (OR CABIN) EQUIPMENT

Cockpit equipment includes a quantity indicating system, shutoff valves, and regulators. In some liquid oxygen systems the shutoff valve may be part of the regulator. On aircraft equipped with ejection seats, a composite quick-disconnect is also provided.

Quantity Indicating Systems

Liquid oxygen quantity indicating systems generally consist of a quantity gage and a warning light. The quantity is indicated in liters instead of pounds per square inch pressure, because the pressure in a liquid oxygen system remains constant until the liquid oxygen is depleted.

On some installations there is one warning light for each user, on others there may be two. In the latter case, one light is to warn the user in case system delivery pressure drops below normal, the other light warns of a low supply of liquid oxygen. The maintenance of the quantity indicating and warning light systems is the responsibility of the AE rating.

Shutoff Valves

Shutoff valves are installed in the oxygen system to facilitate opening and closing of the flow of oxygen to the crewmen. Figure 8-4 illustrates a typical manually operated, two-position valve. As shown in figure 8-1, this valve opens and closes flow from the plenum to the seat mounted personnel services disconnect. The valve has an inlet port, outlet port, and a relief port. The pressure relief valve is located in the inlet chamber to protect against excessive system pressures. Any excessive pressure is vented off through this relief valve, regardless of the position of the valve.

When the lever handle is lifted against the pressure of the lever handle spring, the lever is disengaged from its notch in the retainer cap and can be moved to the ON position. As the linkage moves through the guide slot in the retainer cap, the linkage mechanism lifts the teflon disc type poppet from its seat, permitting pressure flow through the outlet port. The lever handle locks in either the ON or OFF position when the spring-loaded lever drops into the respective position slot. A definite lifting action on the control lever is required to unlock it and move it from one position to another.

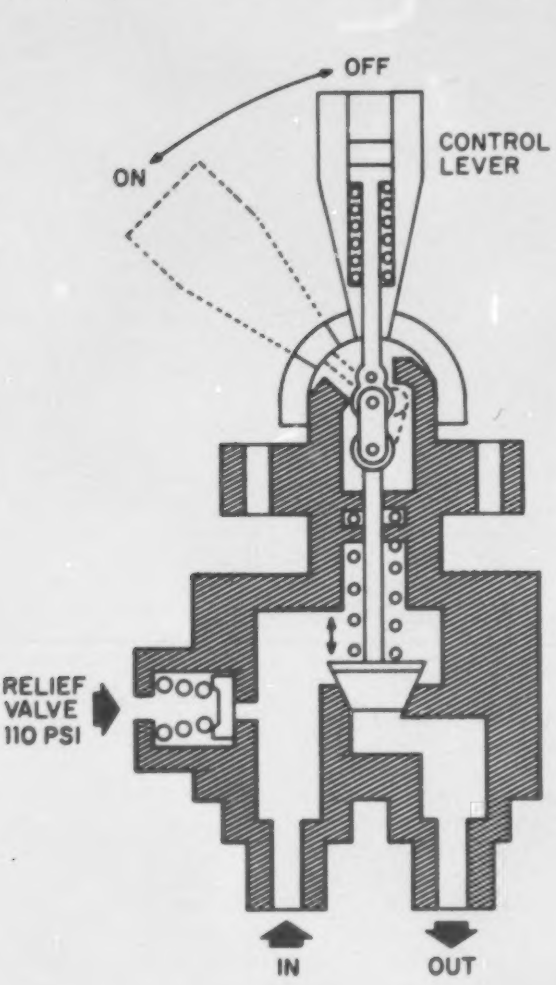
Liquid oxygen systems which incorporate console-mounted regulators do not have separate shutoff valves. The shutoff valve is part of each regulator.

Composite Quick-Disconnect Couplings

The purpose of the composite quick-disconnect coupling is to provide a single-point connection for automatically and quickly connecting and disconnecting the pilot with the aircraft services; that is, to oxygen, anti-g, communications, and pressurization/ventilation air. A typical installation is described and illustrated in chapter 6 with additional coverage provided in chapter 7.

Regulators

Regulators used with liquid oxygen systems may be the console-mounted type, seat-mounted type, or the miniature mask-mounted type. The



AM.1170
Figure 8-4.—Oxygen shutoff valve.

console-mounted type regulator is normally used in large multiplace aircraft such as the E-1B and the E-2A. The A-6 aircraft provides an example of a seat-mounted diluter demand oxygen regulator. The smaller seat-mounted regulator and the miniature mask-mounted regulators are especially designed for use with aircraft which have ejection seats. Since the console-mounted type regulators are discussed in chapter 7 only the seat-mounted and the miniature mask-mounted type are described here.

SEAT-MOUNTED REGULATOR.—The Model 29252-A-1 seat-mounted, diluter demand type regulator illustrated in figure 8-5 works in much the same manner as the console-mounted regulator discussed in chapter 7. That is, it controls the flow and pressure of warmed gaseous oxygen according to the demands of the user. It also controls the mixture of oxygen with cabin ambient air in proportions varying with the cabin altitude that is sensed by the regulator air ratio aneroid. The regulator is equipped with a manual control knob on the diluter portion to allow the user to select 100 percent oxygen whenever desired. All oxygen going to the regulator passes through the seat personnel services disconnect. Oxygen going from the regulator to the face mask again passes through the personnel services disconnect. Upon ejection, the emergency oxygen supply is delivered to the regulator through the disconnect and regulated in the same manner as the aircraft's oxygen supply.

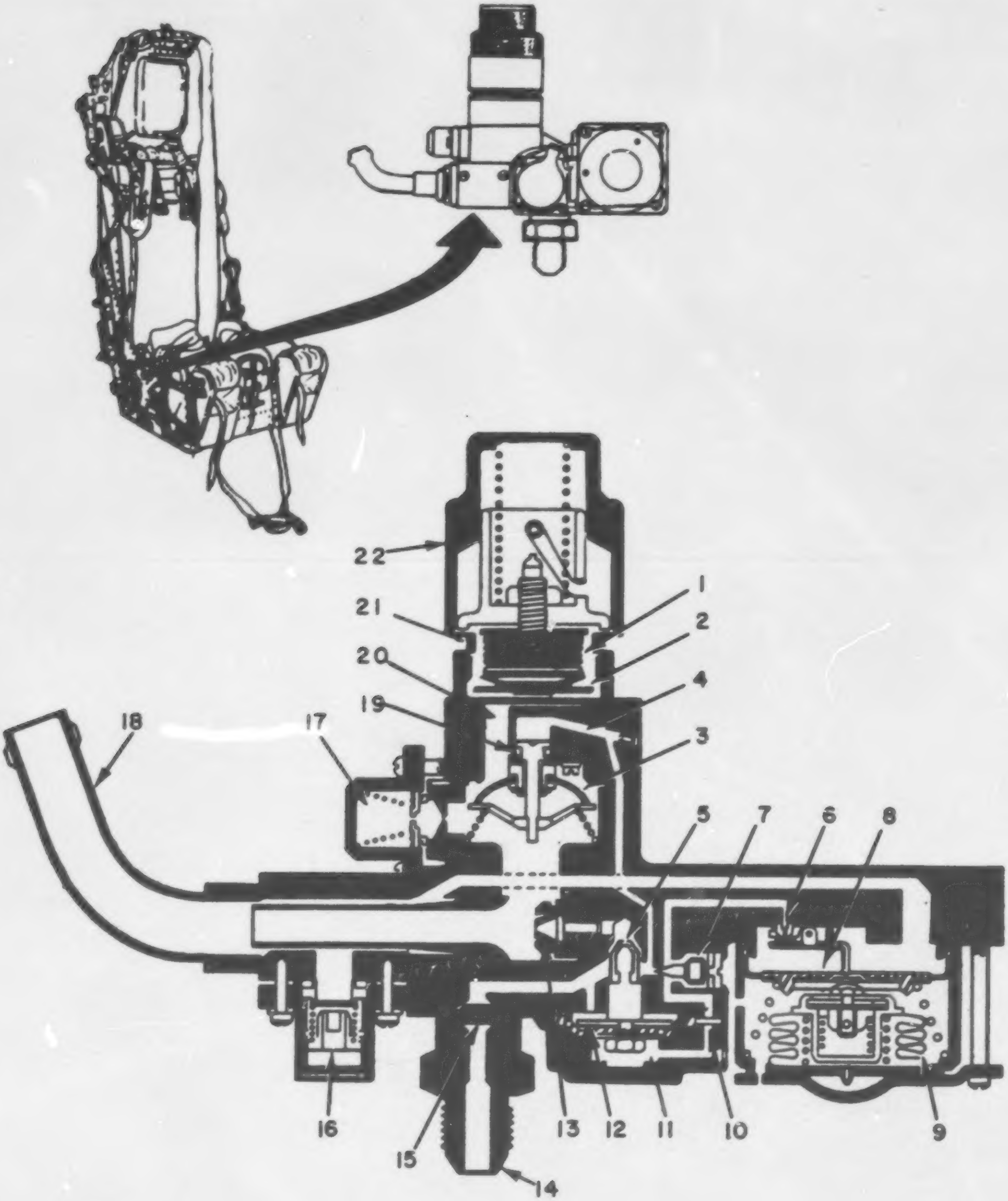
In the static, or no flow condition, the following conditions exist (fig. 8-5):

Oxygen pressure at approximately 75 psi enters the regulator, passes through the inlet filter and flows past the demand valve to the inlet pressure chamber (4), where it acts against piston (19). The piston moves downward against pressure of the check valve (3) spring, leaving the check valve free to open and permit the intake of ambient air through the air dilution port (21).

Incoming oxygen also flows past the needle valve (7), building up pressure in the demand valve lower chamber equal to that of inlet pressure exerted on the opposite side.

When the oxygen user inhales, causing a dynamic or flow condition, a pressure differential is created across the breathing diaphragm (8). The diaphragm moves upward, actuating the linkage to open the small pilot valve (6). Pressure in the demand valve lower chamber is bled through the pilot valve, causing the demand valve diaphragm to flex and open the demand valve. Oxygen then flows past the demand valve and through nozzle (13) where it is mixed with ambient air and delivered to the oxygen face mask.

The velocity of the oxygen as it exits the nozzle causes a pressure reduction that draws ambient air from the cabin into the regulator when the dilution knob is open. The knob provides a manual means of selecting either air dilution or 100 per cent oxygen. The air ratio aneroid, attached to the dilution air throttling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AM.1171

Figure 8-5.—Seat mounted-diluter demand regulator (model 29252-A-1).

Nomenclature for figure 8-5.

1. Air ratio aneroid.
2. Throttling plate.
3. Check valve.
4. Inlet pressure chamber.
5. Demand valve.
6. Pilot valve.
7. Needle valve.
8. Breathing diaphragm.
9. Pressure breathing aneroid.
10. Orifice plate.
11. Demand valve lower chamber.
12. Demand valve diaphragm.
13. Nozzle.
14. Inlet fitting.
15. Inlet filter.
16. Relief valve.
17. Dump valve.
18. Outlet fitting.
19. Piston.
20. Air dilution chamber.
21. Air dilution port.
22. Dilution knob.

plate, expands and contracts metering the flow of air to give the correct percentage of dilution as the altitude changes. In a depressurized cabin, the air ratio aneroid will automatically close off all dilution air at approximately 30,000 feet altitude and 100 per cent oxygen will be provided up to approximately 50,000 feet, which is the service ceiling of the regulator.

The regulator delivers automatic safety pressure, not in excess of 2 inches of water pressure, from sea level up to 35,000 feet. It delivers automatic pressure breathing from 35,000 to 50,000 feet, not to exceed 18 inches of water pressure.

The check valve (3) prevents the loss of safety pressure oxygen through the air dilution ports and also provides automatic air shutoff at higher altitudes when the regulator is on dilution.

If the oxygen inlet pressure drops below 40 psi, the piston in the inlet pressure chamber backs off, allowing the spring-loaded retainer to close the check valve, closing off dilution air. Without this automatic shutoff feature, anoxia could occur if virtually all of the breathing gas were ambient air.

The dump valve (17) is provided as an aid in exhalation. Due to a response lag in the regulator, the demand valve does not close off at the exact moment of exhalation. This lag could result in a pressure buildup in the mask, breathing hose, and the regulator. The dump valve relieves this pressure at the end of each flow cycle (inhalation/exhalation).

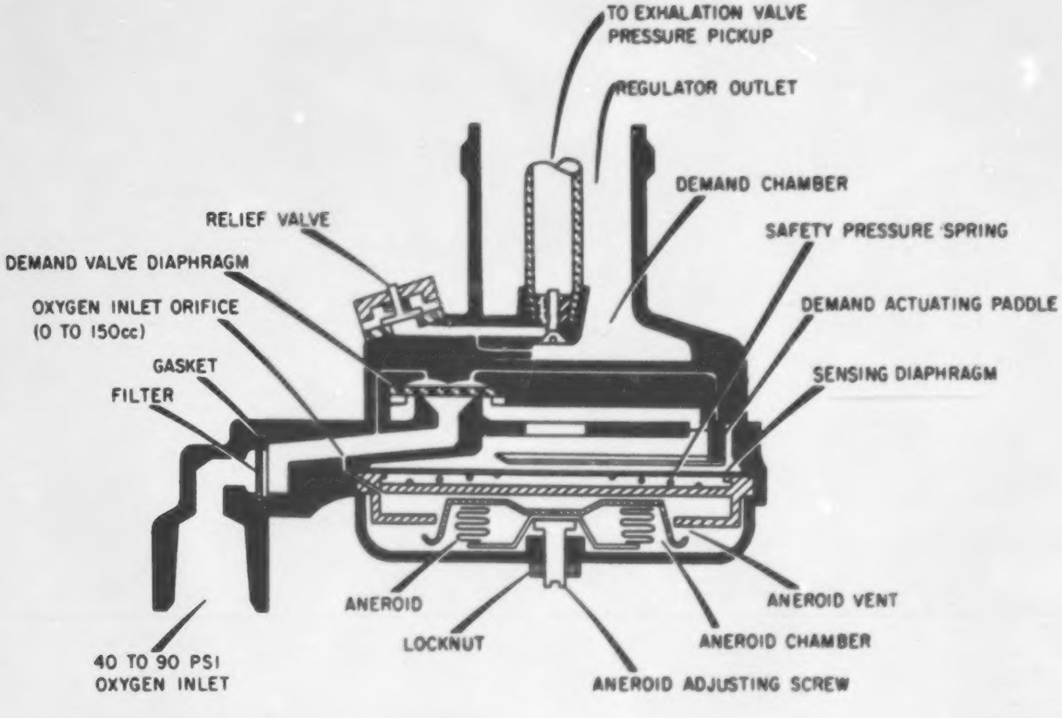
The relief valve (16) protects the oxygen user from excessive pressure. Whenever the regulator outlet pressure reaches 24 inches of water, the valve opens. As the pressure is relieved and drops to 16 inches of water, the relief valve reseats and again becomes leak-tight.

This regulator is designed to be used with the A13-A oxygen mask.

MINIATURE OXYGEN BREATHING REGULATOR.—The miniature oxygen breathing regulator shown in the cutaway view in figure 8-6 is intended primarily for use in aircraft having a low-pressure liquid oxygen system and ejection seats. It is often referred to as a miniature mask-mounted regulator. The regulator integrates with the A13-A oxygen breathing mask. It is designed so that with an inlet pressure of 40 to 90 psig it will deliver 100 per cent oxygen automatically to the user between the altitudes of 0 and 50,000 feet. The regulator incorporates automatic safety pressure buildup to a maximum of 2 inches of water pressure below 35,000 feet and automatic pressure breathing for altitudes about 35,000 feet, depending on the regulator adjustment (internal tolerances). Weighing only 2.3 ounces and measuring approximately 2 5/8 inches in length and width, the regulator is mounted on the oxygen mask or the user's harness.

Oxygen at the controlled system pressure, warmed to a comfortable temperature, flows into the regulator inlet port to the demand valve diaphragm. A small passage from the inlet line sends this pressure to the backside of the diaphragm; thus, the demand valve diaphragm is pressure balanced except for the slight imbalance caused by an area advantage on the backside of the diaphragm, which provides a positive sealing force.

The vacuum caused by inhalation causes the sensing diaphragm to tilt downward, pushing


TO EXHALATION VALVE
PRESSURE PICKUP
REGULATOR OUTLET
DEMAND CHAMBER
RELIEF VALVE
SAFETY PRESSURE SPRING
DEMAND VALVE DIAPHRAGM
DEMAND ACTUATING PADDLE
OXYGEN INLET ORIFICE
(0 TO 150cc)
GASKET
SENSING DIAPHRAGM
FILTER
ANEROID
ANEROID VENT
LOCKNUT
ANEROID CHAMBER
40 TO 90 PSI
OXYGEN INLET
ANEROID ADJUSTING SCREW

PR.56

Figure 8-6.—Cutaway view Model 226-20004 miniature mask oxygen regulator.

down the demand actuating paddle. As the paddle is forced downward, its base is lifted from a seat which seals a second passageway from the backside of the demand valve diaphragm. Raising the paddle base allows flow from this area which causes a pressure drop behind the demand valve diaphragm and allows inlet pressure to lift the diaphragm from its seat and oxygen flow occurs.

Safety pressure is obtained by the safety pressure spring, which deflects the sensing diaphragm, causing flow through the unit until the force created by mask pressure equals the force of the spring. This returns the sensing diaphragm to a balanced condition.

Automatic pressure breathing is obtained by diverting a small volume bleed from the inlet passage to the aneroid chamber. This bleed is normally vented from the aneroid cavity past the area labeled "aneroid vent" (fig. 8-6). At the altitude at which pressure breathing is to begin, the lip of the aneroid comes in contact with the seat, closing off the aneroid vent and building up pressure which reacts on the sensing diaphragm. The pressure lifts the sensing diaphragm, causing flow until the mask pressure exerts a force on the sensing diaphragm equal to the force exerted by pressure buildup in the aneroid chamber.

The relief valve on the unit acts as a pilot device to open the exhalation valve of the mask. This is accomplished by isolating the pressure pickup of the exhalation valve with the tube in the outlet port of the unit, so that the exhalation valve is compensated only by the pressure sent to it by the exhalation valve pickup tube.

LIQUID OXYGEN SYSTEM OPERATION

The liquid oxygen system shown in figure 8-1 is an example of a two-place system. This system converts liquid oxygen to gaseous oxygen and delivers it to the crew. The oxygen source of this system is a supply of liquid oxygen stored in a 10-liter converter. At atmospheric pressure, liquid oxygen boils at -297° F and changes to gaseous oxygen in a volumetric ratio of 1/862 (liquid/gas). System pressure is maintained at 55 to 110 psi by a pressure control valve and a pressure relief valve. The converter in this system is installed in an aft equipment compartment, and provisions are included for the installation of a second converter for long-range missions.

Through a process of controlled evaporation within the converter assembly, liquid oxygen is converted to gaseous oxygen as required by the occupants of the aircraft. The oxygen is delivered to the cockpit after being warmed to a safe breathing temperature in the heat exchanger. The flow of oxygen is controlled in the cockpit by the shutoff valves.

The major part of the operation of the liquid oxygen system is controlled automatically by the units which make up the converter assembly. The liquid oxygen converter has three sequences of operation—fill, buildup, and supply. (see fig. 8-7.) In the supply sequence, the converter alternates between the economy and demand modes of operation.

FILL SEQUENCE

The fill sequence begins automatically when the servicing trailer hose filler nozzle is connected to the filler port on the fill, vent, and buildup valve. The hose nozzle, when attached to the fill valve, actuates a plunger within the valve which places the valve in the fill and vent condition. (See A, fig. 8-7.) The valve, when in this position, provides an opening from the top of the converter to the atmosphere. This opening is utilized to vent gaseous oxygen during filling and liquid oxygen after the converter is full. During transfer, liquid oxygen flows into the converter through a passage located in the bottom of the converter. This arrangement allows gaseous oxygen to vent through the converter top as it is being displaced by liquid flow in the bottom. When the converter is full, liquid flows overboard through the vent line, giving an indication that the converter is full. Removal of the filler hose nozzle from the fill valve automatically places the converter in the buildup sequence.

BUILDUP SEQUENCE

The buildup sequence (B, fig. 8-7) begins when the filler hose is removed from the converter. This sequence provides for rapid pressure buildup to system operating pressure. During this sequence, liquid oxygen from the converter fills the buildup coil by gravity feed. Liquid in the coil absorbs heat from the ambient air around the coil and vaporizes, causing the pressure to build up. The gaseous oxygen formed in the coil then circulates through the pressure closing valve and back to the top of the converter. This causes more liquid to flow into the buildup coil. This circulation continues to build up pressure until approximately 75 psi is reached. At this pressure, the pressure closing valve is forced closed, thus stopping further pressure buildup. When this occurs, the converter is ready for operation and oxygen is available at the supply outlet. A pressure relief valve which is set at approximately 110 psi is installed in the converter system to relieve excessive pressure.

SUPPLY SEQUENCE

The supply sequence of the liquid oxygen system consists of two modes of operation—the economy mode, in which gaseous oxygen is fed from the converter, and the demand mode, in which oxygen flows from the converter as a liquid and vaporizes to a gas in the feed line.

In the economy mode of operation (C, fig. 8-7) limited demand upon the system allows the converter to supply gaseous oxygen directly as a result of drawing off the gaseous oxygen stored within the top of the converter. At approximately 82 psi, the pressure opening valve unseats and allows gaseous oxygen to flow from the converter to the supply system. Oxygen then flows from the upper (gas) portion of the converter, rather than the liquid side. When the amount of oxygen demanded by the crew exceeds the supply capabilities of the economy mode, the pressure opening valve closes. As the crew continues to draw upon the oxygen supply, the supply system pressure becomes lower than that of the converter. When a pressure differential of 5 psi occurs, the differential check valve opens (D, fig. 8-7) and allows liquid oxygen to flow into the supply line thus creating the demand mode. Converter pressure will build up while the system is operating in the demand mode. As this pressure again approaches 82 psi, the pressure opening valve will again unseat, switching the supply sequence back into the economy mode. The converter automatically switches itself back and forth between the economy and demand modes while supplying oxygen to the crew.

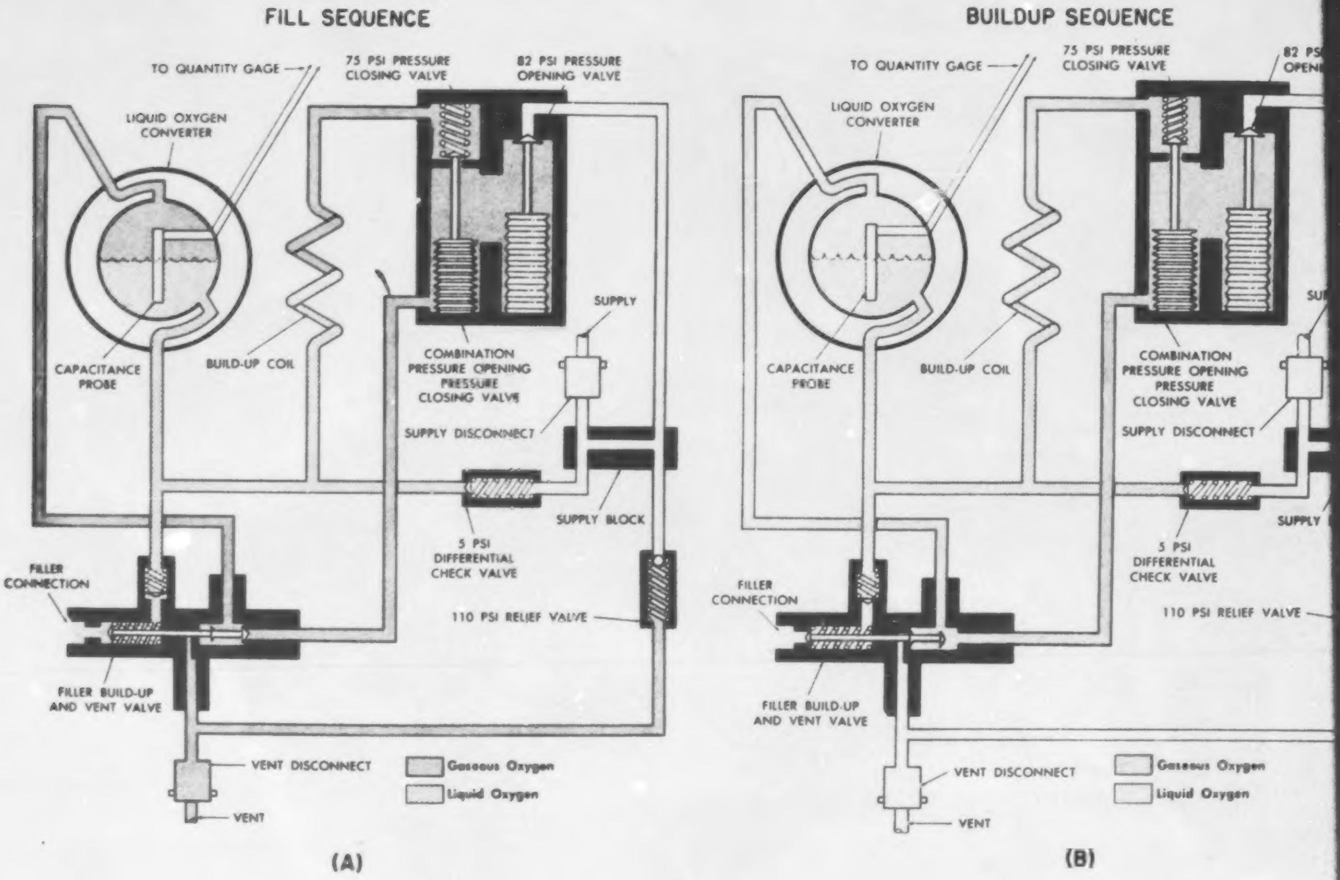
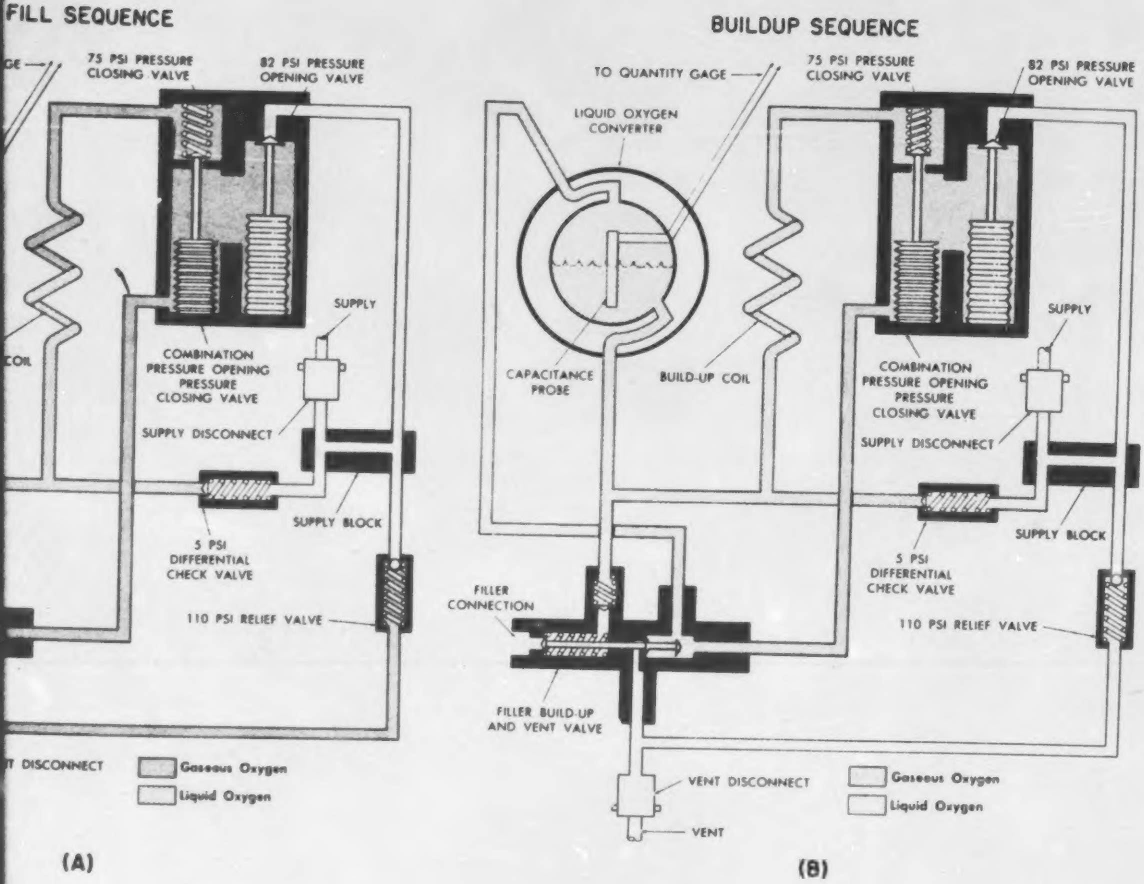

FILL SEQUENCE
TO QUANTITY GAGE
75 PSI PRESSURE CLOSING VALVE
82 PSI PRESSURE OPENING VALVE
LIQUID OXYGEN CONVERTER
SUPPLY
CAPACITANCE PROBE
BUILD-UP COIL
COMBINATION PRESSURE OPENING PRESSURE CLOSING VALVE
SUPPLY DISCONNECT
SUPPLY BLOCK
5 PSI DIFFERENTIAL CHECK VALVE
FILLER CONNECTION
110 PSI RELIEF VALVE
FILLER BUILD-UP AND VENT VALVE
VENT DISCONNECT
VENT
Gaseous Oxygen
Liquid Oxygen
(A)
BUILDUP SEQUENCE
TO QUANTITY GAGE
75 PSI PRESSURE CLOSING VALVE
82 PS
OPEN
LIQUID OXYGEN CONVERTER
SU
CAPACITANCE PROBE
BUILD-UP COIL
COMBINATION PRESSURE OPENING PRESSURE CLOSING VALVE
SUPPLY DISCONNECT
SUPPLY
5 PSI DIFFERENTIAL CHECK VALVE
FILLER CONNECTION
110 PSI RELIEF VALVE
FILLER BUILD-UP AND VENT VALVE
VENT DISCONNECT
VENT
Gaseous Oxygen
Liquid Oxygen
(B)

Figure 8-7.—Liquid oxygen converter operation.


FILL SEQUENCE
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75 PSI PRESSURE CLOSING VALVE
82 PSI PRESSURE OPENING VALVE
COIL
COMBINATION PRESSURE OPENING PRESSURE CLOSING VALVE
SUPPLY
SUPPLY DISCONNECT
SUPPLY BLOCK
5 PSI DIFFERENTIAL CHECK VALVE
110 PSI RELIEF VALVE
T DISCONNECT
Gaseous Oxygen
Liquid Oxygen
(A)
BUILDUP SEQUENCE
TO QUANTITY GAGE
LIQUID OXYGEN CONVERTER
75 PSI PRESSURE CLOSING VALVE
82 PSI PRESSURE OPENING VALVE
CAPACITANCE PROBE
BUILD-UP COIL
COMBINATION PRESSURE OPENING PRESSURE CLOSING VALVE
SUPPLY
SUPPLY DISCONNECT
SUPPLY BLOCK
5 PSI DIFFERENTIAL CHECK VALVE
110 PSI RELIEF VALVE
FILLER CONNECTION
FILLER BUILD-UP AND VENT VALVE
VENT DISCONNECT
VENT
Gaseous Oxygen
Liquid Oxygen
(B)

Figure 8-7.—Liquid oxygen converter operation.

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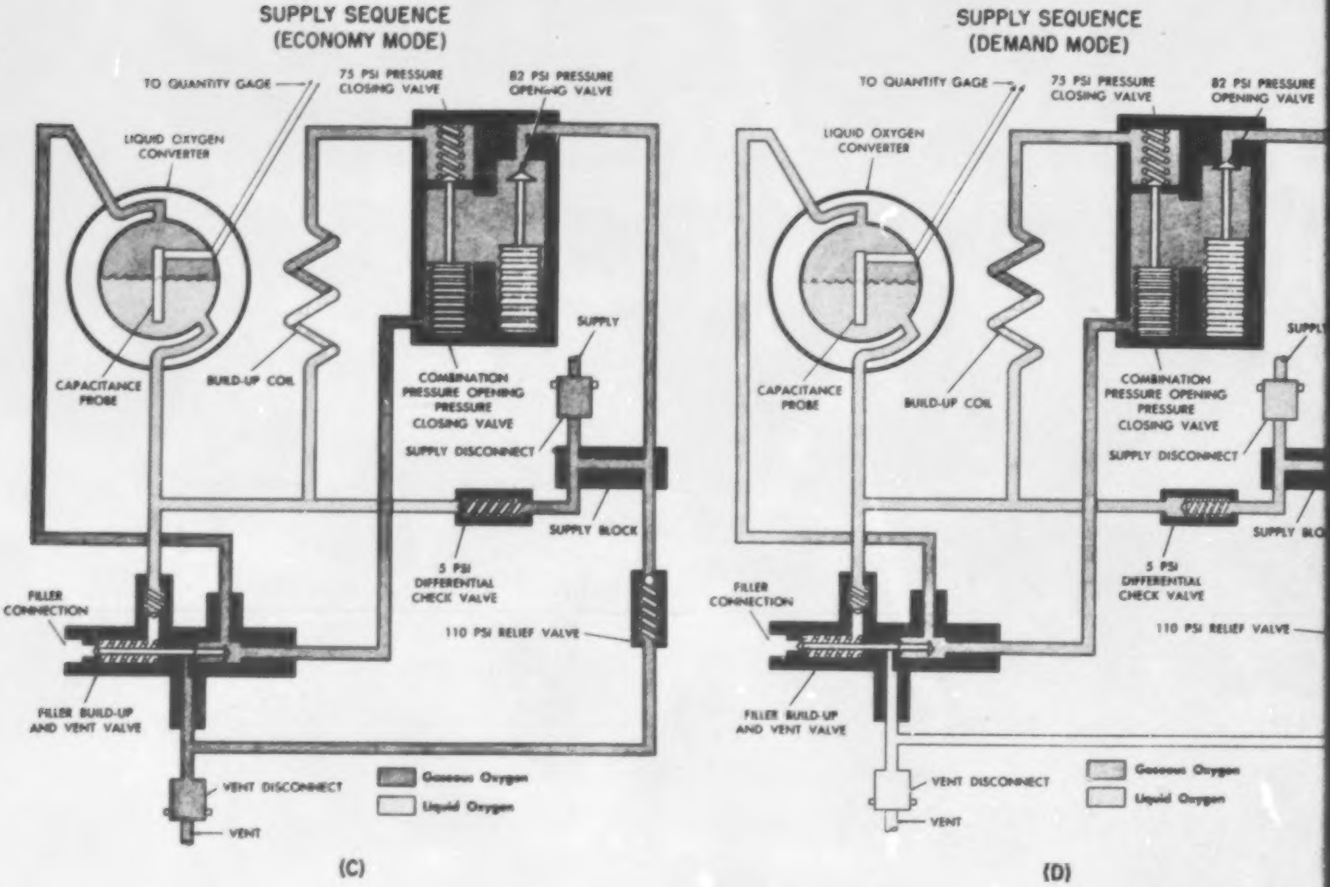
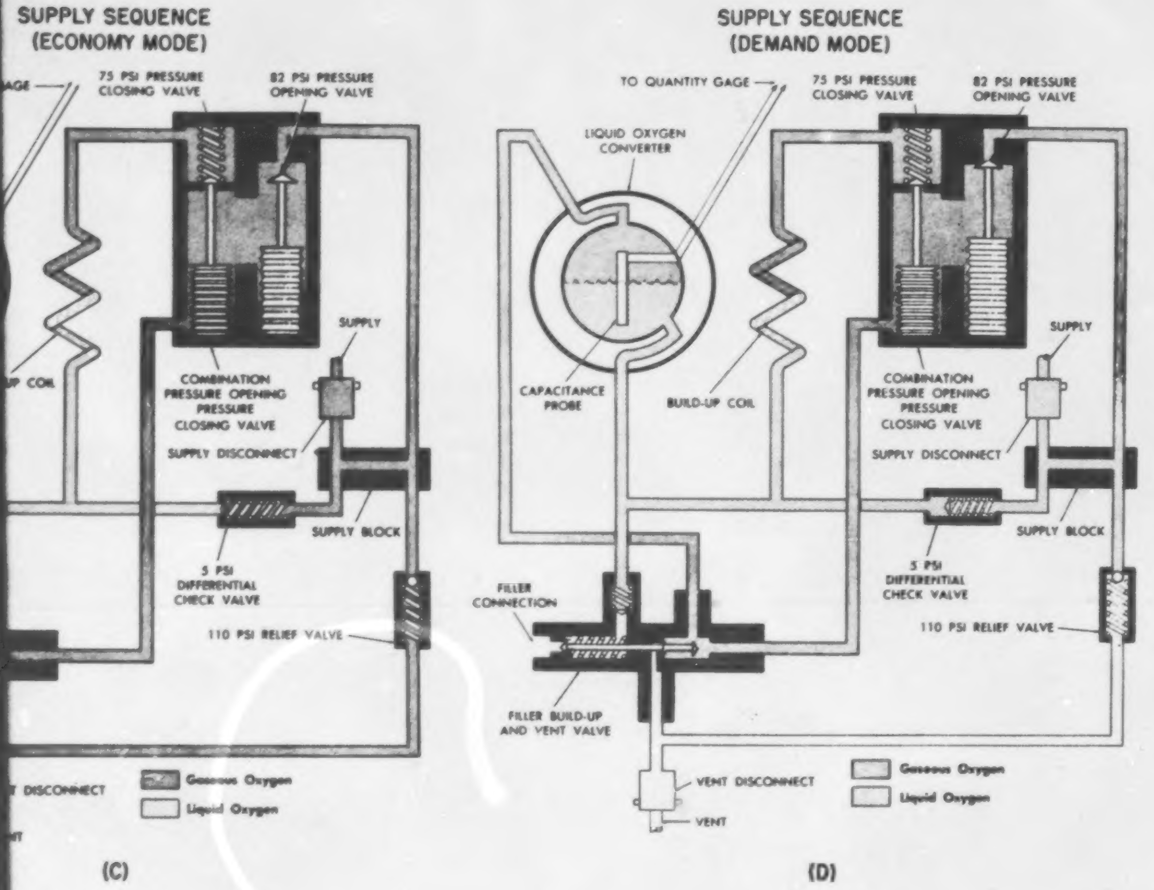

SUPPLY SEQUENCE (ECONOMY MODE)
TO QUANTITY GAGE
75 PSI PRESSURE CLOSING VALVE
82 PSI PRESSURE OPENING VALVE
LIQUID OXYGEN CONVERTER
CAPACITANCE PROBE
BUILD-UP COIL
COMBINATION PRESSURE OPENING PRESSURE CLOSING VALVE
SUPPLY
SUPPLY DISCONNECT
SUPPLY BLOCK
5 PSI DIFFERENTIAL CHECK VALVE
110 PSI RELIEF VALVE
FILLER CONNECTION
FILLER BUILD-UP AND VENT VALVE
VENT DISCONNECT
VENT
Gaseous Oxygen
Liquid Oxygen
(C)
SUPPLY SEQUENCE (DEMAND MODE)
TO QUANTITY GAGE
75 PSI PRESSURE CLOSING VALVE
82 PSI PRESSURE OPENING VALVE
LIQUID OXYGEN CONVERTER
CAPACITANCE PROBE
BUILD-UP COIL
COMBINATION PRESSURE OPENING PRESSURE CLOSING VALVE
SUPPLY DISCONNECT
5 PSI DIFFERENTIAL CHECK VALVE
110 PSI RELIEF VALVE
FILLER CONNECTION
FILLER BUILD-UP AND VENT VALVE
VENT DISCONNECT
VENT
Gaseous Oxygen
Liquid Oxygen
(D)

Figure 8-7.—Liquid oxygen converter operation—Continued.


SUPPLY SEQUENCE
(ECONOMY MODE)
AGE
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82 PSI PRESSURE OPENING VALVE
UP COIL
COMBINATION PRESSURE OPENING PRESSURE CLOSING VALVE
SUPPLY
SUPPLY DISCONNECT
SUPPLY BLOCK
5 PSI DIFFERENTIAL CHECK VALVE
110 PSI RELIEF VALVE
T DISCONNECT
Gaseous Oxygen
Liquid Oxygen
NT
(C)
SUPPLY SEQUENCE
(DEMAND MODE)
TO QUANTITY GAGE
75 PSI PRESSURE CLOSING VALVE
82 PSI PRESSURE OPENING VALVE
LIQUID OXYGEN CONVERTER
CAPACITANCE PROBE
BUILD-UP COIL
COMBINATION PRESSURE OPENING PRESSURE CLOSING VALVE
SUPPLY
SUPPLY DISCONNECT
SUPPLY BLOCK
5 PSI DIFFERENTIAL CHECK VALVE
110 PSI RELIEF VALVE
FILLER CONNECTION
FILLER BUILD-UP AND VENT VALVE
VENT DISCONNECT
VENT
Gaseous Oxygen
Liquid Oxygen
(D)

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Figure 8-7. —Liquid oxygen converter operation—Continued.

LIQUID OXYGEN SYSTEM MAINTENANCE

The AME is responsible for the maintenance of aircraft liquid oxygen systems. Maintenance includes performing periodic inspections, purging, repairing leaks, and removing and replacing components, lines, and fittings, as necessary. Regulators and converters are removed and replaced by the AME, but are tested, checked, and repaired by the personnel of the PR rating. Electrically operated quantity indicating system components are maintained by the personnel of the AE rating.

DRAINING CONVERTERS

Many of the maintenance tasks performed on aircraft liquid oxygen systems requires that the converter be drained. The following is a general procedure for draining a converter:

1. Remove the converter in accordance with the instructions contained in the applicable Maintenance Instructions Manual.

WARNING: Because of the hazards involved in handling liquid oxygen, only qualified personnel should drain liquid oxygen systems. Personnel handling liquid oxygen must always wear the special protective gloves, face shield, and clothing provided for this purpose.

2. Place the converter in a safe place for the draining operation.

CAUTION: When draining a liquid oxygen converter, insure that the area is open and free of unnecessary personnel and that fire extinguishing equipment is readily available. The immediate area around the converter and draining area must be free of any grease, oil, or other combustible materials.

3. Attach a drain line to the supply disconnect coupling of the converter, as shown in figure 8-8. The drain line is used to deflect the liquid oxygen into the drain container. The drain line may be constructed from a length of rigid tubing and connected to a spare female half of a supply disconnect coupling. In some cases it is possible to remove the flexible supply line from the aircraft liquid oxygen system for use as a drain line.

CAUTION: Only tubing which is approved for use in liquid oxygen systems should be used for the construction of a converter drain line. After the drain line has been constructed, all traces of grease or oil must be removed from the line.

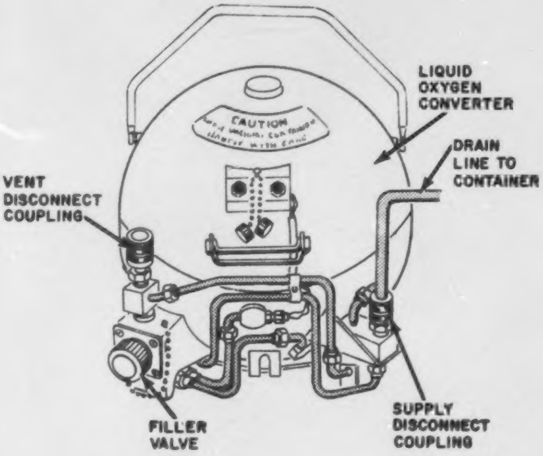

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Figure 8-8.—Draining liquid oxygen converter.

NOTE: When the drain line disconnect coupling is connected to the converter supply port, it opens the check valve in the supply disconnect coupling. This allows the LOX to flow out of the drain line. Therefore, insure that the drain line is over a drain container of suitable size prior to making the connection.

4. With the drain line connected to the converter supply disconnect, allow the converter to stand until completely drained.

5. When liquid oxygen no longer flows from the drain line, remove the drain line from the supply disconnect coupling.

NOTE: Liquid oxygen drained from an aircraft liquid oxygen converter should be allowed to evaporate. No attempt should ever be made to return the drained liquid oxygen to an aircraft system or servicing trailer.

PURGING

Purging is the procedure by which contaminants are flushed from the converter with hot, dry gaseous nitrogen or unheated dry gaseous oxygen if nitrogen is not available. The gaseous nitrogen should be heated to a minimum of 150°F and not more than 250°F. One of the principal contaminants is moisture, which may short the converter quantity indicating probes. The purging gas is heated so that any moisture in the converter will be removed.

Liquid oxygen systems which are serviced with the converter installed must be purged every calendar (or equivalent) inspection. Systems which are serviced by replacement (replacement of the empty converter with a full one) should be purged every 30 days. Liquid oxygen systems which have been left empty for several hours or left open due to replacement of parts must be purged. Any evidence of contamination also requires purging. NOTE: Many times, it will be necessary to purge LOX converters to eliminate a short in the quantity indicating probe.

The following is a general purging procedure.

1. Remove the converter and drain the liquid oxygen.

NOTE: Liquid oxygen systems should be purged in accordance with the instructions contained in the applicable Maintenance Instructions Manual. Some manufacturers recommend purging the converter and the aircraft system separately. Others recommend purging the system with the converter installed.

2. If time permits, allow the system to warm up to ambient temperature. This will conserve large quantities of gas.

3. Connect a regulated source of dry, water-pumped gaseous nitrogen to a purging device as shown in figure 8-9. Connect the purging device to the converter fill valve using a fill valve nozzle adapter (supplied as part of the purging

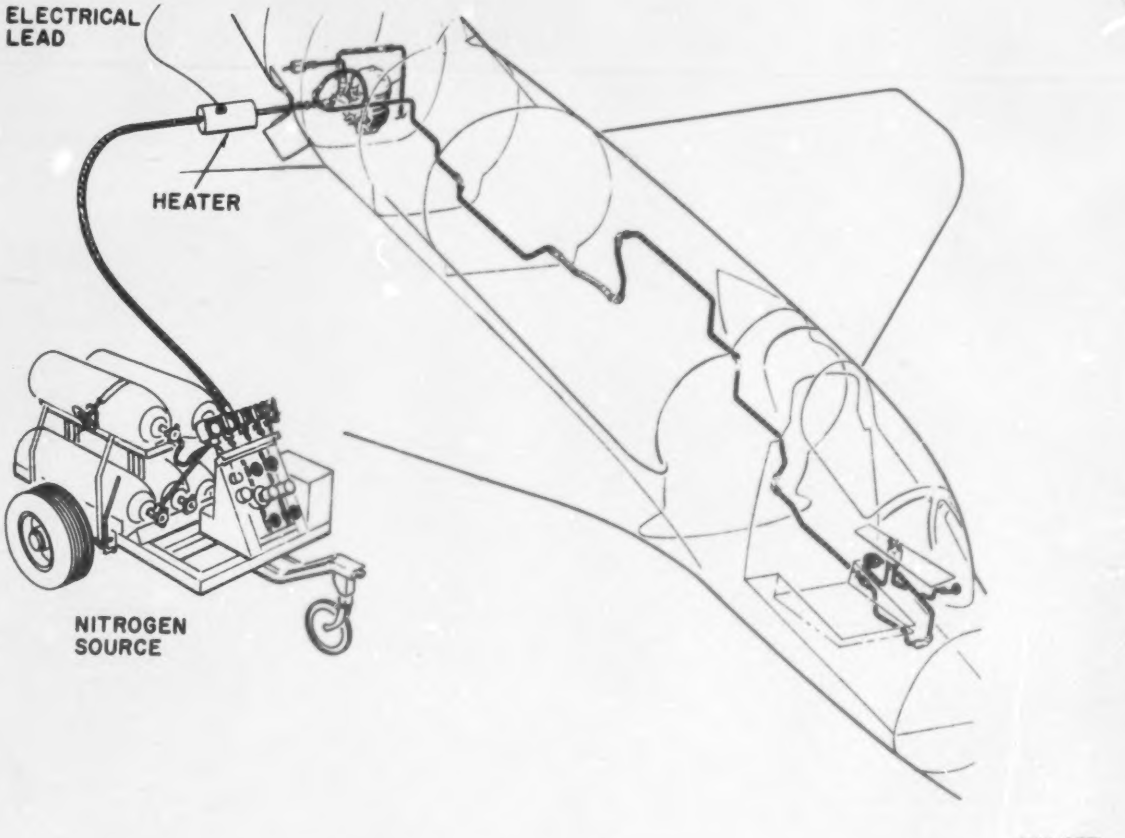

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Figure 8-9.—Purging the converter.

device). Connect the purging device to a suitable electrical source. CAUTION: Unless the electrical cable is properly grounded there is danger of shock.

CAUTION: Use only approved, dry, water-pumped nitrogen when purging oxygen systems. Oil-pumped nitrogen should never be used. Like other compressed gases nitrogen cylinders are color coded. Water-pumped nitrogen cylinders are gray with two black bands. Oil-pumped nitrogen cylinders are gray with one black band.

4. Regulate the nitrogen supply pressure from 10 to 50 psi, preferably 30 psi. This will allow a sufficient amount of nitrogen to flow through the converter. The purging device will provide 250° F (maximum) purging gas under these conditions.

5. Pass the heated nitrogen through the converter or system for at least 2 hours.

6. Disconnect the electrical supply from the purging device and shut off the flow of nitrogen.

7. Disconnect the purging device and turn off system shutoff valves (in the case of purging the converter and system at the same time).

8. As soon as the purging procedure is finished, fill the system with liquid oxygen.

9. Conduct a sniff test. (In this test, liquid oxygen is drained from the converter into a clean glass beaker in which has been placed a piece of filter paper. The beaker is covered and the liquid is allowed to evaporate. When the liquid has evaporated, the cover is removed and the person performing the test smells to determine if any odor is present.)

10. Using an oxygen mask, smell the aircraft oxygen supply to detect odors. If odors persist after the purging operation, or if a short is still indicated in the probe, repeat the purge.

REPAIRING LEAKS

Since oxygen leakage is very dangerous, leaks in threaded connections should be completely eliminated. Also, leakage rate tends to increase with time and vibration. If leaks cannot be eliminated without excessive torquing, the leaking connection should be disassembled and the fittings replaced. Torque values for flared tube fittings are shown in table 3-4 and for pipe thread fittings in table 3-6.

Because of the explosive nature of an oxygen grease mixture, only the compounds approved by a military specification should be used on oxygen fittings. The compounds are used to prevent thread seizure and leaks, and should be used carefully and sparingly. Coat the male threads only and immediately insert it into the female fitting. Do not dip the fitting into the thread compound. The compound must not be used on flared-tube fitting straight threads. Extreme care must also be taken to prevent the compound from entering the fitting, and to prevent contamination of the thread compound with oil or grease.

Flared-tube fittings which are leaking may be tightened to the torque values as shown in table 3-4. If leakage persists, the fitting should be disassembled and the fitting or lines replaced.

INSTALLATION AND TESTING OF COMPONENTS

Extreme care must be exercised when installing units in an oxygen system. The life of the pilot and crew depends on the thoroughness with which the AME does his job.

All maintenance of liquid oxygen systems must be done in accordance with the instructions contained in the applicable Maintenance Instructions Manual. The AME assigned to do liquid oxygen system maintenance should also be familiar with the various instructions pertaining to handling liquid oxygen and maintenance of the related equipment.

The actual removal and installation procedures used in maintaining liquid oxygen systems will vary from one aircraft to another; however, the following precautions will apply to almost any aircraft system.

1. Use only tubing assemblies which have been tested, cleaned, capped, and properly identified as oxygen lines. CAUTION: If lines are fabricated locally, insure that only clean, oil-free tubing and fittings are used. Also insure that no hydraulic fluid is used in the fabrication procedure.

2. Use only the type of fittings specified for the particular oxygen system. Never use fittings with pitted or otherwise disfigured cones or imperfect threads.

3. It is MANDATORY that EXTREME CAUTION be exercised with regard to cleanliness of hands, clothing, and tools. It must be emphasized that all items which come into contact with the oxygen system must be free of dirt, oil, or grease.

4. Use the thread compound which is approved under specification MIL-T-5542C.

5. When installing tubing assemblies between fixed units, the tube assembly should align without the use of undue force.

6. The torque values specified for the particular oxygen system should be strictly adhered to when tightening the fittings.

7. If a section of line is left open or disconnected during an installation, the open fittings must be covered with suitable caps or plugs. When making connections, be certain that no lint, dust, chips, or other foreign material is allowed to enter the oxygen system.

8. Upon completion of the installation of a tube assembly or component, a pressure check of the system should be conducted. The system should be pressurized and the connections checked with a leak-test solution conforming to specification MIL-L-25567B. After the connections have been checked, the leak-test solution should be washed off with clean water.

9. The aircraft liquid oxygen system should be purged after the replacement of any component or tubing assembly.

10. The type of clothing and footwear that is worn when maintaining and servicing a liquid oxygen system is an extremely important factor. Do not wear anything that will produce sparks or static electricity, such as nylon clothing or shoes with steel taps or hobnails. Oxygen-permeated clothing will burn vigorously—a most painful way to die.

11. When servicing a liquid oxygen system, insure that only oxygen conforming to specification MIL-O-27210D is used. Oxygen procured under Federal Specification BB-O-925A is intended for technical use and should NOT be used in aircraft oxygen systems.

12. After the completion of repairs, always perform an operational check of the system and make the required tests to insure that the oxygen is safe for use by the pilot and crew.

Servicing of liquid oxygen systems is recorded on the Support Action Form. Converters and regulators removed for check and test during the calendar inspection of the aircraft are forwarded to the Intermediate level maintenance activity, utilizing a Work Request, OpNav 4790/36. This form is utilized to request work or assistance that is beyond the requesting activity's capability and does not involve repair of aeronautical material. If the component fails the check and test, it is returned to the requesting activity and subsequently turned in to supply for repair, utilizing the multicopy Maintenance Action Form. A description of the various maintenance management forms along with their uses is provided in OpNav Instruction 4790.2 (Series).

LIQUID OXYGEN SERVICING TRAILERS

The AME is responsible for the servicing of aircraft liquid oxygen systems. He must be able to operate the various types of liquid oxygen servicing trailers. The AME is also responsible for the preoperational/daily and calendar inspection of the servicing trailer as well as miscellaneous repairs.

The purpose of the liquid oxygen servicing trailer is to provide a portable means of filling aircraft liquid oxygen converters. A general description of one type servicing trailer is given in this section.

LIQUID OXYGEN SERVICING TRAILER (TYPE NO 4)

The liquid oxygen servicing trailer shown in figure 8-10 is the type NO 4, manufactured by Ronan and Kunzl. It is typical of equipment currently in use and therefore is the only trailer discussed in this chapter. The other types of liquid oxygen servicing trailers are similar in operation, but differ in tank capacity and running gear. The lower profile of some types allows them to pass under low wings of aircraft and other obstructions encountered during shipboard and line operations.

Description

The type NO 4 servicing trailer is a 50-gallon unit. Basically, this unit consists of a liquid oxygen tank, a transfer hose assembly, and a trailer. The necessary controls are mounted in a hooded area on the rear of the tank. The hose is stowed in a rack mounted on the side of the tank, as shown in figure 8-10.

Figure 8-11 is a schematic diagram of the liquid oxygen tank and related equipment. As shown in the diagram, the unit consists of two tanks (inner and outer), separated by an annular space which is packed with a powder type insulating material. This annular space is evacuated to a high degree (forming a vacuum).

The tank is equipped with all the control valves, gages, pressure relief valves, and blowout rupture discs necessary for simple and safe operation. Practically all this related equipment is located either inside the control hood or on the outside of the control hood which

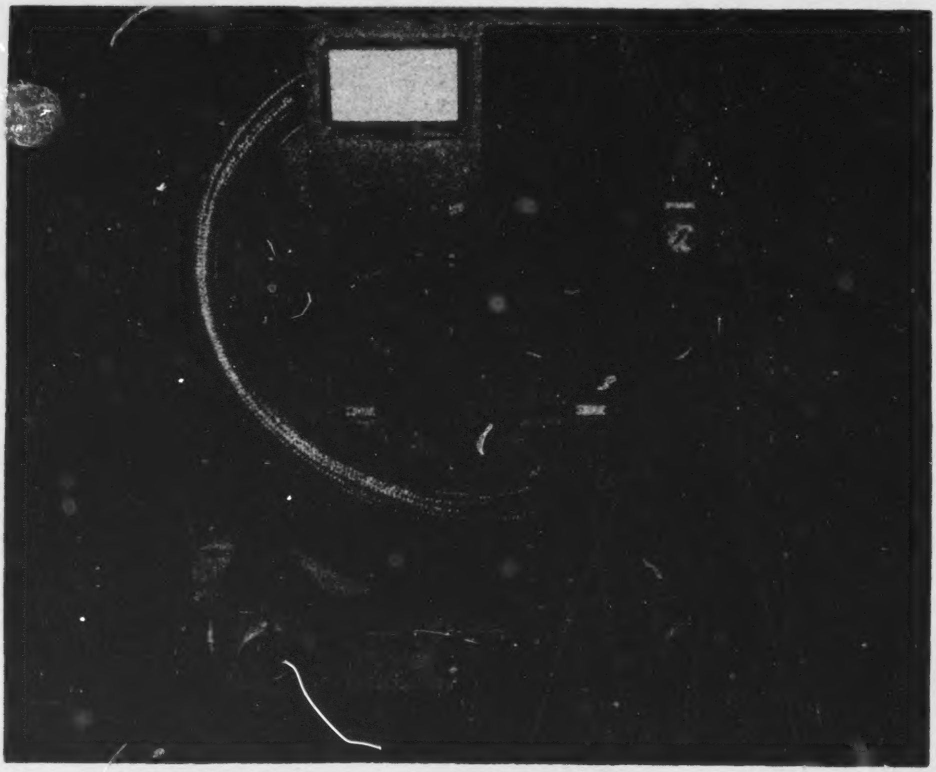

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Figure 8-10.—Type NO 4 liquid oxygen servicing trailer.

is attached to the rear of the tank. (See fig. 8-12.)

The vent line and fill-drain line connect the inner tank to the external piping. Both lines emerge in the control hood. The pressure buildup coil, which is connected between the vent line and the fill-drain line, operates as a heat exchanger to vaporize liquid oxygen and pressurize the inner tank during the transfer of liquid oxygen.

To prevent excessive pressurization of the inner tank, the tank pressure relief valve and a safety rupture disc are installed in the pressurizing coil line. The rupture disc, located in a weather hood at the front of the tank, is designed to rupture and release the pressure between the inner and outer tanks in the event that the inner tank is damaged.

Three direct reading gages (fig. 8-12) are provided on the control hood—a pressure gage, to indicate the pressure in the inner tank; a differential pressure type capacity gage with a bypass valve; and an electronic battery-operated vacuum gage to indicate the vacuum in the annular space between the inner and outer tanks. In addition, pull-to-test handles for the tank pressure relief valve and the hose pressure relief valve are located on the hood, as well as a fill-drain hose coupling.

The following components are located inside the control hood: a tank pressure relief valve, a vent valve, a fill-drain valve, a pressure

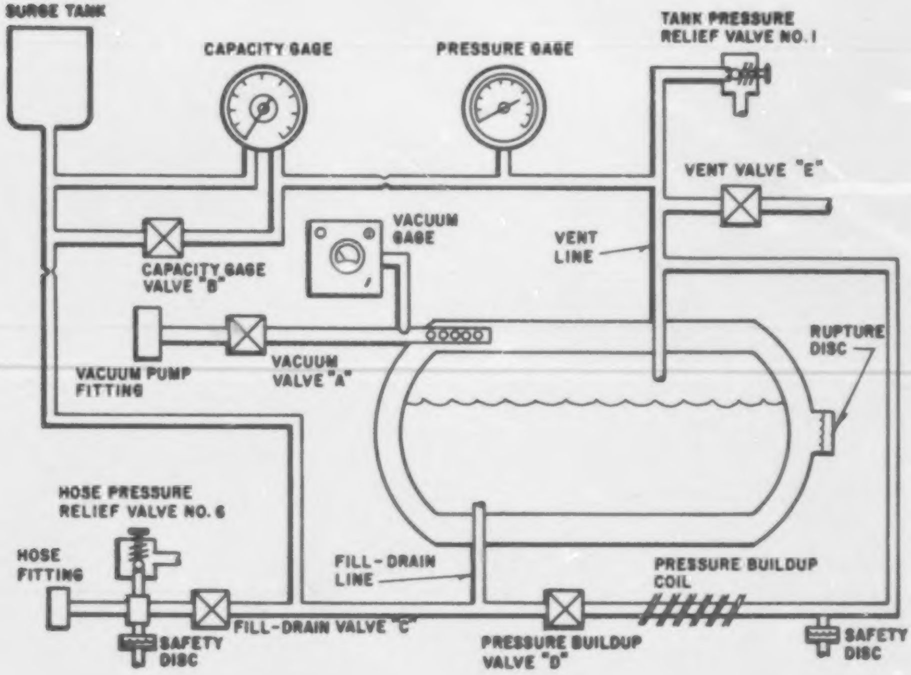
SURGE TANK
CAPACITY GAGE
PRESSURE GAGE
TANK PRESSURE RELIEF VALVE NO. 1
VENT VALVE "E"
VACUUM GAGE
VENT LINE
CAPACITY GAGE VALVE "B"
RUPTURE DISC
VACUUM PUMP FITTING
VACUUM VALVE "A"
HOSE PRESSURE RELIEF VALVE NO. 6
HOSE FITTING
FILL-DRAIN LINE
PRESSURE BUILDUP COIL
FILL-DRAIN VALVE "C"
SAFETY DISC
PRESSURE BUILDUP VALVE "D"
SAFETY DISC

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Figure 8-11.—Liquid oxygen servicing trailer (schematic).

buildup valve, a hose pressure relief valve, a hose pressure safety rupture disc, and a transfer hose purging device.

NOTE: The control valve handles are color coded (as shown in fig. 8-12) for ready identification.

The trailer is equipped with a length of 3/8-inch inside diameter flexible hose. The hose is insulated and has a covering of braided stainless steel. One end of the hose is attached to the fill-drain coupling of the servicing trailer. The other end of the hose is equipped with a filler valve assembly. The filler valve has a dust cover which must be in place at all times when the hose is not in use.

The tank and related equipment are mounted on a four-wheel knuckle-steering utility trailer of all steel construction. The trailer is equipped with a mechanical handbrake assembly, hoisting links, and a tow bar.

Operation

The liquid oxygen servicing trailer is used to store a supply of liquid oxygen and to fill aircraft converters. The valves mounted under the hood on the rear of the tank control the various functions of the trailer. Table 8-1 lists the position of the valves for each function of the trailer.

The filling, pressure buildup, transfer, and storage functions of the NO 4 liquid oxygen servicing trailer are described in the following paragraphs.

FILLING.—Servicing trailers are usually filled from large liquid oxygen storage tanks. These tanks are quite similar in construction and operation to the servicing trailer.

The first step in filling the trailer is to set the trailer control valves in the positions as indicated in table 8-1. After the control valves are set, check the trailer pressure relief valves

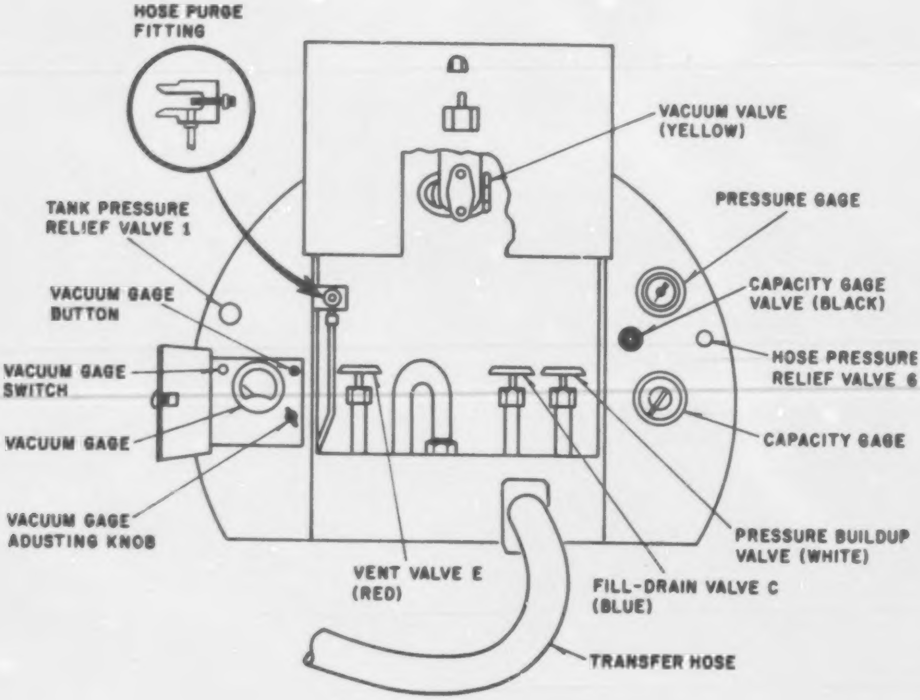
HOSE PURGE FITTING
TANK PRESSURE RELIEF VALVE 1
VACUUM GAGE BUTTON
VACUUM GAGE SWITCH
VACUUM GAGE
VACUUM GAGE ADUSTING KNOB
VENT VALVE E (RED)
FILL-DRAIN VALVE C (BLUE)
TRANSFER HOSE
VACUUM VALVE (YELLOW)
PRESSURE GAGE
CAPACITY GAGE VALVE (BLACK)
HOSE PRESSURE RELIEF VALVE 6
CAPACITY GAGE
PRESSURE BUILDUP VALVE (WHITE)

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Figure 8-12.—Liquid oxygen servicing trailer control panel.

(tank pressure and hose pressure) for freedom of operation. This is done by pulling the handles several times.

Purge the storage tank hose by allowing a little liquid oxygen to flow out of the hose. CAUTION: Always drain liquid oxygen into a clean drain pan or can. After the storage tank hose has been purged, attach the hose to the servicing trailer fill-drain coupling. Open the fill-drain valve on the trailer, then open the fill-drain valve on the storage tank. The fill-drain valve on the storage tank should be opened only enough to permit partial flow until the transfer hose and servicing trailer have been cooled down. This requires about a minute and is indicated by a slowing down of the gas escaping from the vent line on the servicing trailer.

Fully open the storage tank fill-drain valve and leave it open until the trailer is full. NOTE: When the liquid spurts from the trailer vent line, the tank is full.

Close the fill-drain valve on the storage tank, then close the fill-drain valve on the trailer. Next, relieve the pressure in the transfer hose by pulling the hose pressure relief valve. Disconnect the transfer hose.

CAUTION: Personnel filling liquid oxygen servicing trailers must wear the special protective gloves, face shield, and clothing provided for this purpose.

WARNING: Some liquid may remain in the transfer hose even after the relief valve has been pulled. Use caution at all times when disconnecting the transfer hose. Keep it pointed away from personnel.

After an interval of 10 minutes (to let the liquid quiet down), the trailer should be checked (using the capacity gage) to see if the tank is full. The capacity gage bypass valve is closed to allow the capacity gage to operate. NOTE: The capacity gage bypass valve must be reopened as soon as the gage reading is taken.

PRESSURE BUILDUP.—In order to transfer liquid oxygen from the servicing trailer to an aircraft converter, the trailer tank is pressurized. This is called the pressure buildup condition. The servicing trailer is put in the buildup condition by placing the control valves in the positions shown in table 8-1.

The pressure relief valves (hose pressure and tank pressure) should be checked for freedom of operation prior to setting the buildup condition.

The pressure buildup valve (valve D which is white) should be opened slowly while observing the tank pressure gage. As will be noted on the trailer schematic shown in figure 8-12, opening the pressure buildup valve will allow the liquid oxygen to flow into the buildup coil. This causes the liquid to evaporate, pressurizing the space above the liquid.

The pressure should not be allowed to exceed 50 psi. Most converters may be filled with a trailer pressure of 30 psi. NOTE: When using equipment other than the Ronan and Kunzl, type NO 4, refer to the applicable manual for the operating pressure.

The pressure buildup valve should be closed when the desired pressure is reached. In order to maintain tank pressure, it may be necessary to open the pressure buildup valve as transfers are made. Transfer pressure must be maintained in order to completely empty the trailer tank. If transfer pressure is lost when the liquid in the tank has been reduced to approximately 10 gallons, it may be necessary to refill the tank before pressure buildup can be reestablished.

After completing the necessary transfers and provided no further transfers are to be made in the next 4 hours, the vent valve (valve E which is red) should be opened to release the tank pressure. All valves should then be set for the storage condition as indicated in table 8-1. A closed vent valve on a tank in the storage condition would raise the tank pressure to the point where the tank pressure relief valve would open. If the tank pressure relief valve failed, the vent line safety disc would rupture and relieve the pressure.

NOTE: Servicing of aircraft liquid oxygen systems is covered in chapter 10.

STORAGE.—After the filling, buildup, or transfer functions are completed, the liquid oxygen trailer should be returned to the storage condition. In this condition, the trailer controls should be set as indicated by table 8-1. This places the tank in the vented condition. If the tank is completely empty and is not to be refilled immediately, the vent valve (valve E which is painted red) should be closed.

CAUTION: When setting the tank in the various conditions, do not disturb the vacuum valve (valve A which is painted yellow). This valve is used only when pumping down the vacuum space.

VACUUM GAGE OPERATION.—An electronic battery-operated vacuum gage is used to indicate the vacuum in the liquid oxygen trailer

Table 8-1.—Valve positions for type NO 4 trailer functions.

Valve identification			Functions					
Letter	Color	Valve name	Bottom filling	Top filling	Pressure buildup	Transfer	Vacuum pumping	Liquid storage
A	Yellow	Vacuum	Closed	Closed	Closed	Closed	Open	Closed
B	Black	Capacity gage	Open	Open	Open	Open	Open	Open
C	Blue	Fill-drain	Open	Closed	Closed	Open	Closed	Closed
D	White	Pressure Buildup	Closed	Closed	Open	*Closed	Closed	Closed
E	Red	Vent	Open	Open	Closed	Closed	Open	**Open
P	Silver	Top fill	Closed	Open	Closed	Closed	Closed	Closed

* If pressure falls below desired transfer pressure, open valve "D" until desired pressure is obtained.

** Should be closed when tank is empty and not used.

tank annular space. The vacuum in this space is measured in microns on the gage (1,000 microns equals 1mm Hg pressure and 760 mm Hg equals barometric pressure at sea level). Batteries are used to operate the gage. The batteries are located in a plug-in battery pack behind the gage.

NOTE: If the trailer is used in humid or below freezing temperatures, the batteries should be removed from the gage when not in use. The battery pack may be carried by the operator and plugged into the gage for operation.

The vacuum is measured as follows: With the batteries connected, turn on the vacuum gage switch. (See fig. 8-12.) Then depress and hold down the vacuum gage button and observe the needle swing across the dial. Use the vacuum gage adjusting knob to balance the needle at zero. Then release the vacuum gage button, and read the microns of pressure (vacuum) in the insulated space. Turn off the vacuum gage switch after each use. This adds to the service life of the equipment and the battery.

Maintenance

The AME is responsible for a preoperational check of the liquid oxygen servicing trailer and must make the following checks before using the trailer.

1. Perform sniff test for quality of oxygen prior to servicing an aircraft.
2. Handbrake for effective operation.
3. Tires for proper inflation.
4. Thermocouple vacuum gage for an indication of 250 microns or less with battery and cord assembly properly connected.

NOTE: If indication exceeds 250 microns a vacuum pumping of the insulated space is required and should be accomplished by the supporting activity.

5. Capacity gage for adequate oxygen supply indication.
6. Open pressure buildup valve slowly, check pressure gage for adequate tank pressure indication.

NOTE: Transfer pressure should not exceed 50 psi; transfers require 30 to 50 psi.

7. Valves and connecting lines for evidence of leakage under pressure.

NOTE: Leakage can usually be detected by a gradual loss of pressure when no liquid is being withdrawn or by a wet spot on a frosted area at the point of leakage.

8. Check pressure relief valves for proper operation by pulling handles several times.
9. Towbar and safety chains for breaks and secure attachment.
10. Transfer hose:
    a. Coupling nut to tank for tightness.
    b. Service fitting for cleanliness and distortion.
    c. Female filler valve for evidence of leakage under pressure (open fill-drain valve).
    d. Female filler valve for proper operation with valve fitted firmly against purging device allowing a free flow of liquid oxygen.
    e. Filler valve dust cap for secure attachment.
    f. Hose trough for cleanliness.

WARNING: After inspection, close the pressure buildup and fill drain valves; relieve pressure with filler valve fitted firmly against purging device.

NOTE: Thermocouple vacuum gage terminal switch should be in the OFF position when trailer is not in use.

Calendar maintenance of liquid oxygen servicing trailers is performed by the AME assigned to the Intermediate level of maintenance. The inspection is conducted in accordance with the applicable Maintenance Requirements Cards and includes the following elements:

Chassis and tank inspection.
Oxygen delivery system inspection.
Cleaning or replacement of filler and transfer hose filters.
Tank purging and vacuum pumping of the annular space.
Chassis and wheel bearing lubrication.
Functional checkout.

NOTE: All maintenance on the liquid oxygen servicing trailers should be accomplished in accordance with the applicable Maintenance Instructions Manuals, Operation, Service, and Repair Instructions, and other pertinent directives.

Logbook

Personnel in Organizational and Intermediate maintenance activities that operate LOX equipment and service aircraft should maintain a logbook to keep a record of the fillings of the servicing trailer, which aircraft are serviced with each batch of LOX received, a record of switching of converters from one aircraft to another, and any other pertinent data that could prevent downing of all aircraft in an activity if a contaminated trailer is accidentally utilized. With a record of all LOX transactions, all aircraft would not have to be held down pending a sampling and analysis of LOX for suitability for use. Such instances have occurred and resulted in unnecessary testing of aircraft systems that were in fact not serviced with the contaminated trailer.

Contamination Control

Liquid oxygen must be kept free of contamination; otherwise, serious consequences may result. Aviators breathing oxygen with transient odors (contamination) can experience real adverse physical symptoms and disorientation. A contaminated supply may cause noxious and nauseating odors which may adversely affect the pilot's efficiency or cause malfunction of the liquid oxygen system components.

Odors may accumulate in LOX that are not identifiable or detectable by customary analytical methods. However, these odors may be detected by an individual with a reasonably keen sense of smell. Thus, the simple sniff/odor test is an extremely reliable indicator of contamination. It is possible that oxygen samples which have been determined as usable by analytical tests may still produce odors that are unacceptable to the user. Substances causing odors may concentrate to unsatisfactory levels by evaporation of LOX from the system over a prolonged period of time. For this reason some aircraft LOX systems must be purged each calendar inspection period.

Contamination of oxygen is indicated by the presence of any foreign substance in excess of specification requirements or established use limits and/or the presence of any substances which release an undesirable odor or give cause to suspect the suitability of the oxygen for breathing.

The LOX Surveillance Program, explained in depth in OPNAV Instruction 4790.2 (Series) has the primary objective of insuring that each operation involving LOX from procurement or generation to servicing of the aircraft is carried out in strict compliance with established procedures.

All personnel working with liquid oxygen servicing equipment and aircraft systems should take every possible precaution to maintain the quality of the liquid oxygen supply and prevent contaminants from being introduced into the supply during the storage and transfer operations.

To prevent liquid oxygen contamination:

1. Never store liquid oxygen in or around areas in which odors of any type may be absorbed by the liquid oxygen. It should be remembered that liquid oxygen has a high affinity for many gaseous compounds. An example of a poor storage practice is parking the liquid oxygen trailers in the area behind the flight line where jet aircraft are parked.
2. Extreme care should be taken to insure that dirty or oily equipment is never used with liquid oxygen equipment.
3. Keep the liquid oxygen transfer hose filler valve dust cover in place at all times except when actually in use.

NOTE: This dust cover is usually attached to the hose with a chain. This insures that the cover will be readily available at all times.

4. At the beginning of each servicing operation the transfer hose should be purged until liquid flows before connecting it to the aircraft filler valve.
5. Liquid oxygen storage tanks, servicing trailers, or aircraft systems should never be allowed to go dry and be exposed to the atmosphere. When the liquid oxygen equipment is emptied for any reason, it should be closed to the atmosphere in order to prevent the introduction of water vapor or odor.

NOTE: Liquid oxygen storage tanks, servicing trailers, and aircraft systems which have been allowed to run dry must be purged in accordance with the existing directives.

DETECTION.—A sniff or odor test is performed on each servicing trailer to verify the quality of the oxygen prior to servicing. Aircraft converters should be tested for odors as prescribed in the applicable inspection requirements or as soon as possible after a report of in-flight odors by pilot or crewmembers. On reports of inflight odors in the oxygen supply, a sample must also be taken and forwarded to the appropriate laboratory with supporting details of the incident, including history of supply source of the LOX in accordance with the instructions provided in OpNav Instruction 4790.2 (Series). Special identification tags and shipping tags for oxygen samples are available from the supply system. Insulated sampling containers are available from the local NavAirSysCom representative.

The odor test should be made on liquid oxygen systems following every dry purge or at any other time that contamination is suspected. The procedures for performing the odor test on a liquid oxygen servicing trailer are as follows:

1. Cover the bottom of a 400-cubic centimeter beaker or similar container with a clean,

dry piece of filter paper or suitable absorbent paper. Provide a clean transparent glass cover as a means for partially covering the top of the beaker.

2. Connect a short section of clean plastic tubing to the vent line of the trailer purging device to aid in collecting a LOX sample in the beaker.

3. Connect the filler valve of the trailer transfer hose to the purging device and purge the hose for at least 2 minutes.

4. Collect approximately 200 cc of liquid oxygen in the beaker. Keep the beaker covered as much as possible during the collecting of the sample and during the remainder of the test.

CAUTION: Do not hold the beaker with bare hands while collecting the sample.

5. Allow the sample to evaporate to dryness in an area free of air currents and any odors.

6. After the sample has completely evaporated, raise the cover and smell the vapors in the beaker.

7. If odors are detectable in the sampling beaker, purge the equipment as specified in the appropriate Maintenance manual.

Samplings of LOX from aircraft converters are usually obtained with the converter removed from the aircraft. Follow the recommended procedures provided in the applicable aircraft Maintenance instructions manual.

CHAPTER 9

EGRESS SYSTEMS

CANOPY SYSTEMS

The canopy on modern high-performance aircraft serves several purposes. It is designed mainly for the protection and visibility of the pilot and crew. It also serves as an avenue of escape in case of emergency.

The canopy system includes the canopy itself, plus all the components used in opening and closing the canopy for normal entrance and exit, as well as those used in jettisoning the canopy during an emergency. Inspection and maintenance of canopy actuating systems are important responsibilities of the AME.

Two types of canopies—the clamshell type and the sliding type—are commonly used on naval aircraft. (See fig. 9-1.) The clamshell type is hinged aft and opens at the forward end like a clamshell. The sliding type rests on tracks on the fuselage and opens and closes by a sliding action. Figure 9-1 illustrates both types of canopies.

Aircraft manufacturers have designed various methods of actuating the canopy. Normal opening and closing may be accomplished pneumatically (compressed air), electrically, manually, or hydraulically. Emergency jettisoning is generally done pneumatically.

In most instances, more than one method is provided for normal opening and closing of the canopy; thus, if one system fails, the other may be used. The same holds true for jettisoning the canopy.

ELECTRICAL CANOPY SYSTEM

An example of an electrically operated canopy system is that incorporated in the North American T-2A training aircraft.

Description

The T-2A canopy installation is of the clamshell type, hinged at the aft end and opened and closed by reciprocating movement of an actuator rod attached to the canopy near its midsection.

Normal Operation

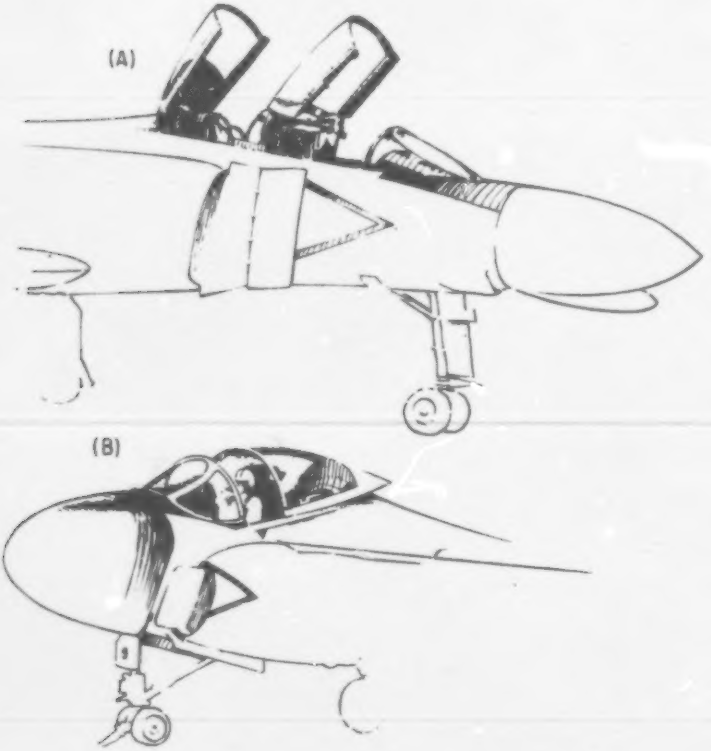
In its normal operation, the T-2A clamshell canopy is electrically controlled and actuated. Three control switches are provided for normal canopy operation. There is one switch for opening and closing the canopy in each of the cockpits and an external switch for opening and closing the canopy from outside the aircraft. The actuator is an electric motor, capable of reverse operation, which drives a rotating gear through reduction gears. This rotating gear is meshed with external threads on a large screwjack which moves up or down, depending upon direction of rotation of the actuator. Upward movement of the screwjack opens the canopy; downward movement closes it. Figure 9-2 illustrates the screwjack and actuator of the electrical canopy system of the T-2A.

Electrical switches known as limit switches are incorporated into the electrical control circuit which automatically shut off the current and stop the actuator motor when the canopy reaches the fully open or fully closed position.

Emergency Operation

The canopy may be forcibly jettisoned from either inside or outside the aircraft. This is accomplished by releasing a pneumatic remover tube located inside the hollow screwjack. A ballistic initiator actuates a release latch which allows air pressure to force the remover tube upward and out of the screwjack and push the canopy up and off the aircraft. Figure 9-3 illustrates the actuator/remover assembly and emphasizes components of the canopy remover as well as the jettison condition.

The remover assembly consists of two tubes, each open at one end only and the smaller



AM.141

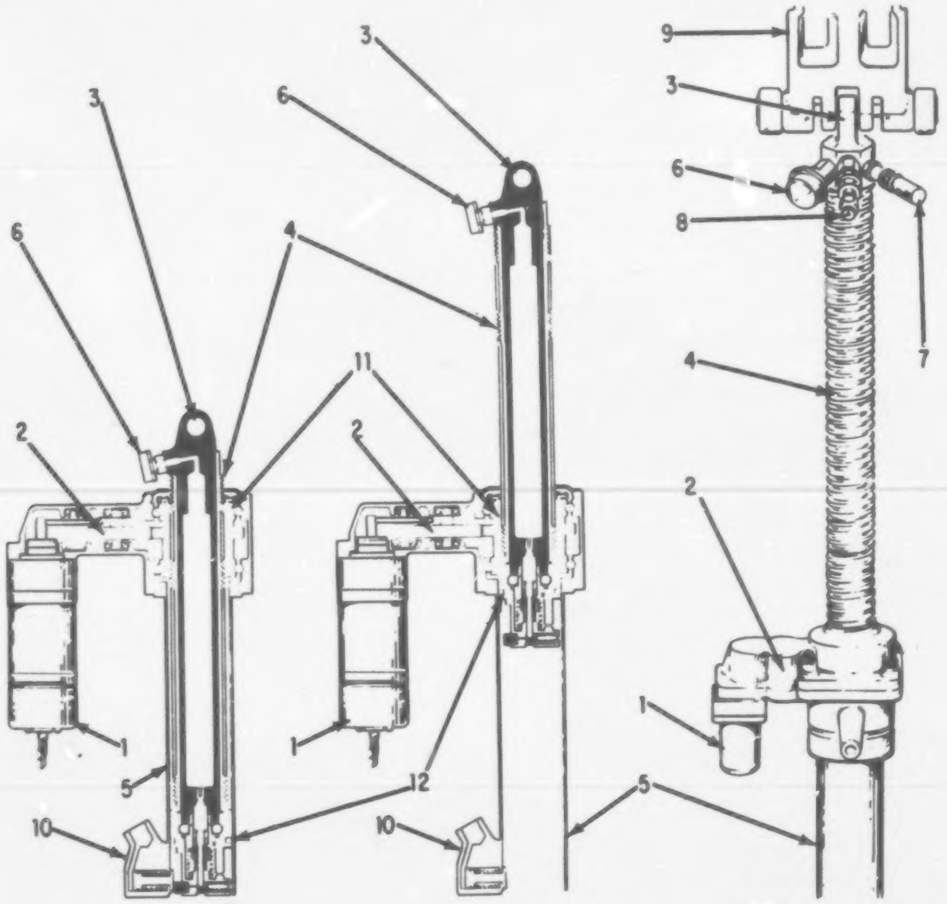
Figure 9-1.—Types of canopies. (A) Clamshell; (B) sliding.

inserted, open end first, into the larger. The addition of an O-ring seal between these two tubes forms an effective air chamber. At the closed end (top) of the inner (remover) tube an air pressure gage, a filler valve, and a pressure relief valve are incorporated.

At the lower end of the inner and outer (screwjack) tubes, a lock mechanism retains the two tubes together during normal canopy actuation. An air pressure charge of 3,000 pounds per square inch is forced into the chamber between the two tubes. This charge is the source of the energy required to remove the canopy forcibly in an emergency. The air filler valve is used to introduce the charge into the remover; the pressure gage is used to check the air-charge periodically as well as act as a control device during air servicing. The relief valve relieves excessive pressures should they build up spontaneously due to thermal expansion in a charged remover tube.

The lock mechanism that retains the actuator/remover sections together is unlatched by a release plunger built into the bottom of the actuator/remover housing. If the screwjack is more than three-fourths of an inch from the down position, the jettison system will be unable to jettison the canopy, because the releasing latch cannot contact the release plunger. (See fig. 9-3.)

The canopy jettison sequence may be initiated automatically during an in-flight emergency simultaneously with initiation of the seat ejection sequence. The canopy jettison sequence may also be initiated manually by means of the canopy emergency release handle located in the forward and aft cockpits or by pulling the external canopy jettison handle located on the left-hand side of



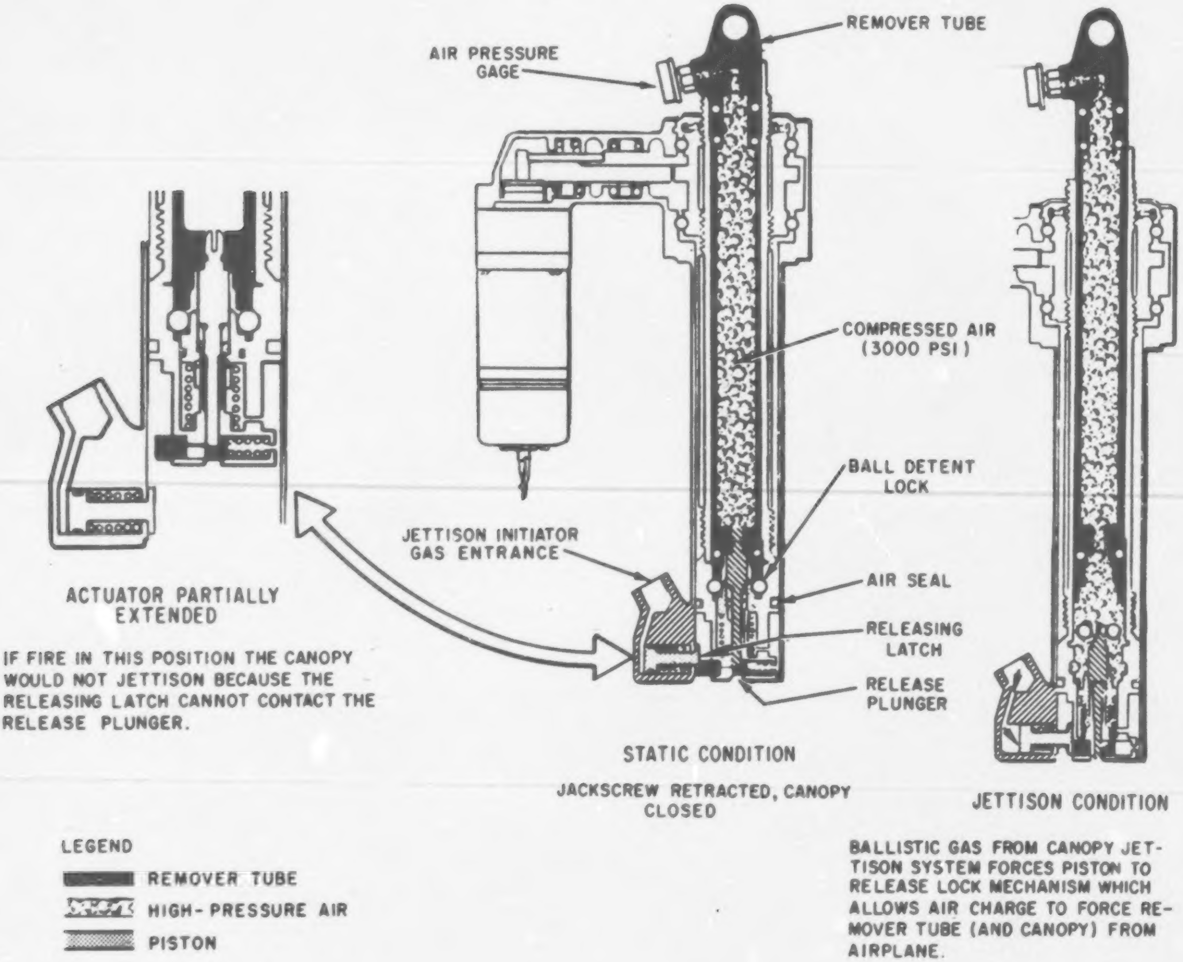
1. Canopy actuator (motor).
2. Reduction gears.
3. Canopy attach point.
4. Actuator/remover tube.
5. Actuator/remover housing.
6. Air pressure gage.
7. Relief valve.
8. Air filler valve.
9. Canopy actuator link.
10. Gas actuated unlocking mechanism.
11. Screw gear.
12. O-ring seals.

Figure 9-2.—Canopy operation components.

the fuselage in the same proximity of the canopy open and close electrical switches.

Regardless of the method used to initiate the canopy jettison sequence, a mechanically actuated gas initiator (a kind of cartridge) is fired. Figure 9-4 shows the forward release handle, the external jettison handle, and the gas initiator. Pulling either the forward or aft canopy release handle approximately 3/4 inch aft, fires the respective initiator.

The external jettison handle (fig. 9-4) is mounted in a spring clip and attached to a 6-foot cable wound into the jettison handle cavity. The opposite end of the cable is attached to the sear pin of the mechanically actuated gas initiator. The cable unwinds as it is pulled until


REMOVER TUBE
AIR PRESSURE GAGE
COMPRESSED AIR (3000 PSI)
BALL DETENT LOCK
JETTISON INITIATOR GAS ENTRANCE
AIR SEAL
RELEASING LATCH
RELEASE PLUNGER
LEGEND
REMOVER TUBE
HIGH-PRESSURE AIR
PISTON

ACTUATOR PARTIALLY EXTENDED

IF FIRE IN THIS POSITION THE CANOPY WOULD NOT JETTISON BECAUSE THE RELEASING LATCH CANNOT CONTACT THE RELEASE PLUNGER.

STATIC CONDITION

JACKSCREW RETRACTED, CANOPY CLOSED

JETTISON CONDITION

BALLISTIC GAS FROM CANOPY JETTISON SYSTEM FORCES PISTON TO RELEASE LOCK MECHANISM WHICH ALLOWS AIR CHARGE TO FORCE REMOVER TUBE (AND CANOPY) FROM AIRPLANE.

AM.1172

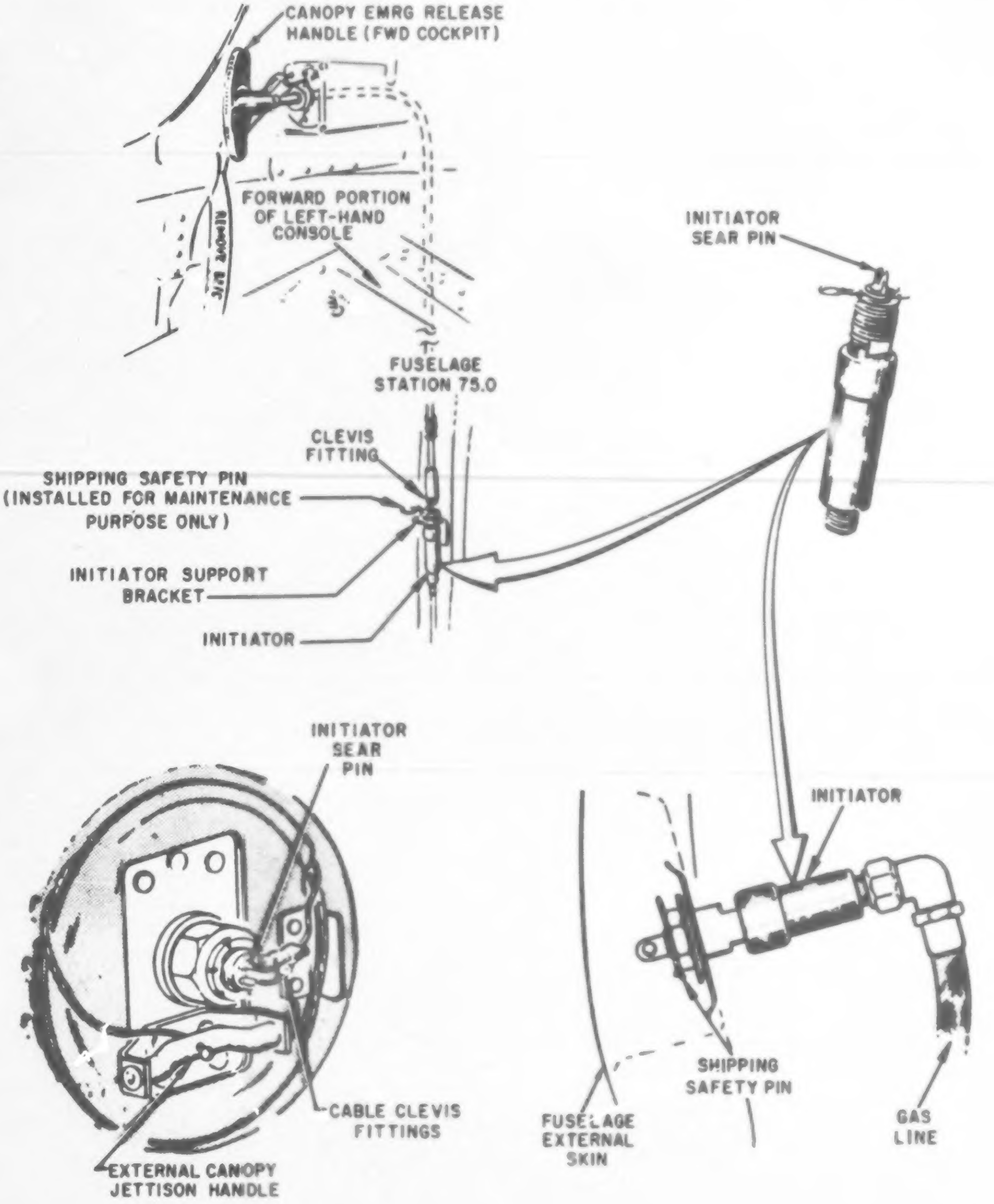
Figure 9-3.—Canopy jettison components and operation.

all slack in the cable is taken up, then the sear pin is pulled and the gas initiator fires.

Expanding gas pressure created by any of the three initiators being fired is routed through flexible steel lines to the bottom of the canopy actuator/remover housing where the gas pressure operates the plunger located in the fixed case at the bottom of the housing. The plunger action releases the mechanical lock at the bottom of the remover tube inside the housing, allowing the high pressure air charge stored in the remover tube to force the tube and canopy from the aircraft.

CARTRIDGE INITIATOR.—A cross sectional view of the cartridge initiator utilized in the T-2A canopy jettison is provided in figure 9-5. The initiator basically consists of a cylinder containing a mechanically operated firing mechanism and a cartridge. The firing mechanism includes the initiator pin, spring, and firing pin enclosed in the firing pin housing. The firing mechanism is held in a safe position by a safety pin which passes through the housing and a groove on the side of the initiator pin.

The initiator is actuated by a cable or rod attached to the initiator pin as shown in figure


CANOPY EMRG RELEASE
HANDLE (FWD COCKPIT)
FORWARD PORTION
OF LEFT-HAND
CONSOLE
INITIATOR
SEAR PIN
FUSELAGE
STATION 75.0
CLEVIS
FITTING
SHIPPING SAFETY PIN
(INSTALLED FOR MAINTENANCE
PURPOSE ONLY)
INITIATOR SUPPORT
BRACKET
INITIATOR
INITIATOR
SEAR
PIN
INITIATOR
CABLE CLEVIS
FITTINGS
EXTERNAL CANOPY
JETTISON HANDLE
FUSELAGE
EXTERNAL
SKIN
SHIPPING
SAFETY PIN
GAS
LINE

AM.1173

Figure 9-4.—Canopy jettison handles and initiators.

9-4. Pulling the cable cocks and releases the spring-loaded firing pin to fire the cartridge.

As is the case with the T-2A, several initiators may be used to trigger a single remotely located pressure-operated device. The gas ports of the initiators are teed into a main gas delivery line so that operation of any of the three initiators in the canopy jettison system will actuate the actuator/release plunger as shown in figure 9-3.

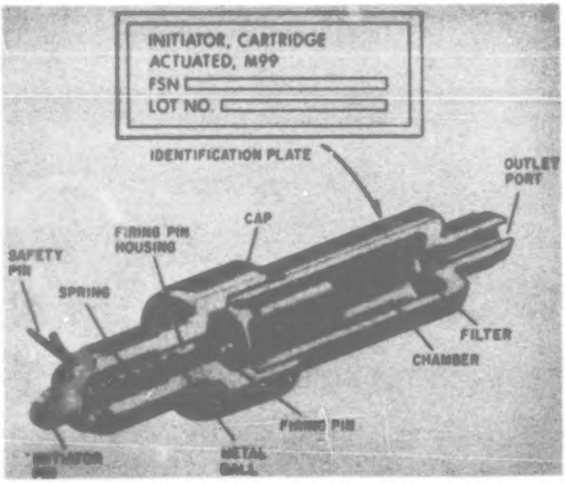
When two or more initiators are utilized in a system, a check valve is installed in the delivery line from each initiator to prevent pressure from the fired initiator from entering the delivery line of the unfired initiators.

Initiator identification and service life data are provided on an identification plate attached to the initiator housing. (See fig. 9-5.) Identification plate data includes a description of the device, the federal stock number, and the lot number. The lot number or the assembly date of the initiator is used in determining its service life. The lot numbered is given in the following manner:

Example: Lot No. 5-XX-0971

1. The number 5 represents the consecutively numbered production lot of each calendar year.
2. The XX represents the assigned code of the final assembler.
3. The 0971 represents the month and year of production. In this case, assembly was commenced in September of 1971.
4. An R after the lot number indicates that the device has been reworked.

The service life of the M99 initiator is presently established at 5 years from the date of assembly or rework, with a maximum of 30 months installed aircraft time allowed. When a new initiator is installed in the aircraft an entry is made in the aircraft logbook of the installation date, lot number, and the computed expiration date. The AME installing the initiator should write this information on the Maintenance Action Form (MAF) so that it may be transcribed from the MAF to the aircraft logbook by personnel in the AZ rating who are charged with that responsibility.



AM.1174

Figure 9-5.—Cartridge actuated initiator.

The service life of a reworked initiator is determined in the same manner as that for new initiators.

NavAir Manual, NavAir 11-100-1, provides general and specific data, nomenclature, handling instructions, and service life limitations for power cartridges and cartridge actuated devices for aircraft and associated equipment.

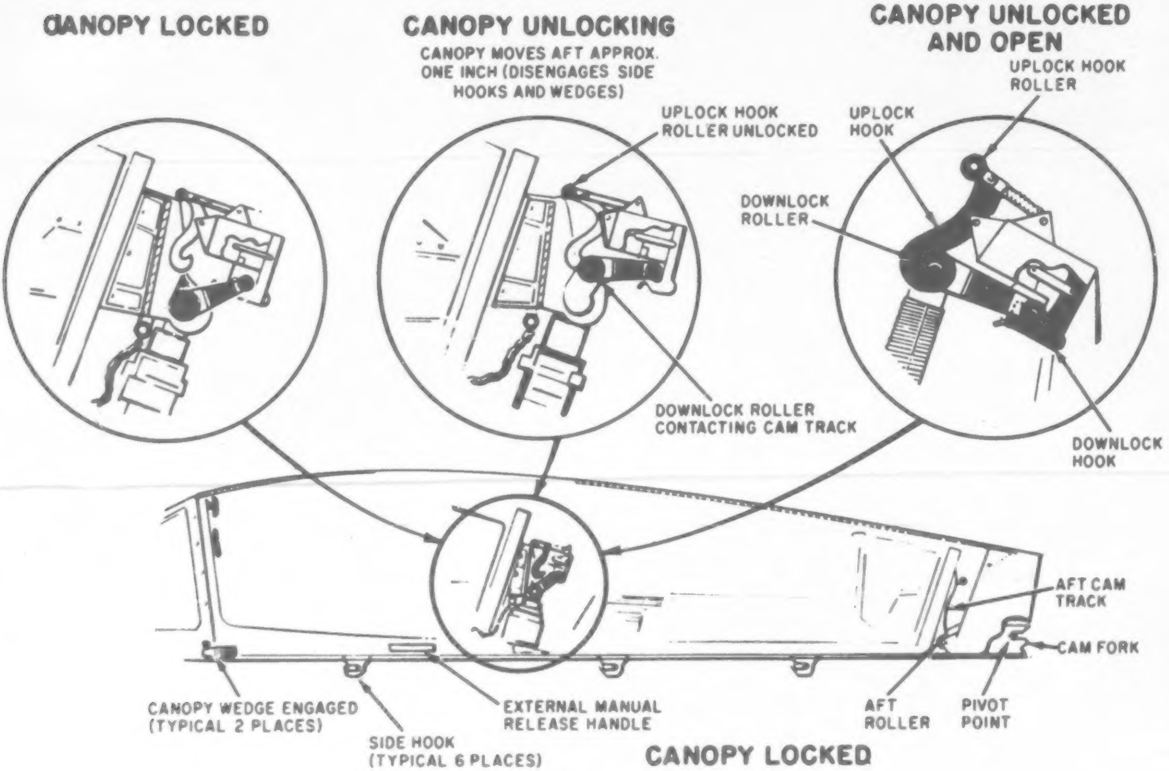
Manual Release Operation

If the canopy actuator/remover becomes inoperative or if it becomes necessary to release the canopy other than in the normal or emergency methods, the canopy can be released manually. The manual release system allows the canopy to be manually unlocked and opened far enough for the pilots to exit the aircraft. The release system is also used during canopy removal operations for maintenance.

The actuator/remover link is the only secure attachment between the canopy structure and the aircraft. Figure 9-6 illustrates the canopy link in the locked, unlocking, and unlocked positions as well as the canopy closing wedge, the six locking hooks, and the cam fork and pivot arrangement. Three manual release handles located in the forward and aft cockpits and on the outside of the left-hand canopy skirt are connected by linkage to the actuator link mechanism. Pulling any one of the handles causes the actuator link hooks to swing aft, releasing the aft end of the actuator link from the canopy connection.

When the canopy is closed, this will allow the canopy to be pushed aft far enough to disengage the side locking hooks and be opened manually by pushing upwards. If an emergency exists, the canopy can be quickly removed from the aircraft by pushing aft and up until the canopy falls clear.

When the canopy is open, manual release requires that one of the handles be pulled over center to position the actuator link hooks in the open position and that the uplock hook be


CANOPY LOCKED
CANOPY UNLOCKING
CANOPY MOVES AFT APPROX. ONE INCH (DISENGAGES SIDE HOOKS AND WEDGES)
CANOPY UNLOCKED AND OPEN
UPLOCK HOOK ROLLER
UPLOCK HOOK ROLLER UNLOCKED
UPLOCK HOOK
DOWNLOCK ROLLER
DOWNLOCK ROLLER CONTACTING CAM TRACK
DOWNLOCK HOOK
AFT CAM TRACK
CAM FORK
CANOPY WEDGE ENGAGED (TYPICAL 2 PLACES)
EXTERNAL MANUAL RELEASE HANDLE
SIDE HOOK (TYPICAL 6 PLACES)
AFT ROLLER
PIVOT POINT
CANOPY LOCKED

AM.1175

Figure 9-6.—Canopy link operating sequence.

disengaged by pushing aft on the uplock hook roller while pushing forward on the canopy.

Maintenance

Prior to performing maintenance on any portion of the canopy jettison system insure that all safety pins are properly installed and that the specific safety precautions peculiar to the system are strictly complied with.

CAUTION: Precautions must be taken to prevent injury by movement of the canopy when working in or near the cockpit of any aircraft. The canopy control handle should be locked in the OPEN position, using the canopy ground safety lock provided.

The canopy emergency release handles in the forward and aft cockpits and the canopy actuator/remover are equipped with flagged ground safety pin devices that prevent accidental initiation of the canopy jettison system. The external jettison handle is not designed to accommodate a ground safety pin. Since the handle is located under a hinged, quick-release skin panel and is equipped with 6 feet of cable slack, jettisoning of the canopy would require positive and purposeful actions.

The only maintenance authorized on the canopy actuator/remover is removal, installation, and servicing with air. The unit should never contain an air charge unless it is installed in the aircraft. The air charge should be released prior to removing the unit from the aircraft.

The ground safety pin for the canopy actuator/remover forms a positive safety lock between the jackscrew and the remover tube. If the remover tube locking mechanism becomes unlocked because of a malfunction or accidental actuation of a canopy jettison system initiator, the pin will prevent the remover from jettisoning the canopy. An unlocked condition would be indicated by binding of the safety pin. If binding occurs it could mean that the safety pin alone is the only thing preventing the canopy from being jettisoned. Never force or pry the safety pin from the actuator/remover. Release the air charge and investigate the cause for the binding.

During maintenance on any of the three jettison handles, associated linkage and plumbing, or the initiators, a shipping safety pin (see fig. 9-4) must be installed in the initiator. Removal procedure for the initiator consists of the following general steps:

1. Install the flagged ground safety pin in the jettison handle (when applicable).
2. Install the pin in the initiator.
3. Disconnect the gas line from the outlet port.
4. Disconnect the jettison handle clevis fitting from the initiator sear pin.
5. Remove the shipping safety pin to accommodate removal of the mounting nut that secures the initiator to its support bracket and withdrawal of the initiator from the bracket hole. Reinstall the safety pin immediately following removal of the initiator from the bracket mounting hole.

CAUTION: When the initiator is being handled with the shipping pin removed, every effort should be made to keep the gas outlet port pointed away from the handler.

Installation procedures for an initiator will normally include checking of the actuating handle(s) for freedom of movement and proper travel. When it has been ascertained that the handle has been properly adjusted in accordance with the Maintenance Instructions Manual the flagged safety pin is inserted in the handle, then the clevis fitting is reconnected to the initiator sear pin. The gas line is not reconnected until all other steps of the installation are completed.

The initiators used in the T-2A canopy jettison system are sealed devices, and maintenance personnel are prohibited from opening them for inspection, cartridge replacement, or any other reason. Initiators that have been fired or are reaching their service life expiration date must be replaced. If an initiator is dropped or damaged in any way during maintenance, or if the sear pin is withdrawn the slightest amount, the initiator should be replaced with a new one.

Rubber hose used in ballistic applications have a service life of 5 years from the date of manufacture with not more than 30 months after installation on an aircraft. Wire braid teflon hose applications have a service life the same as that of the aircraft in which it is installed, unless used. If any initiator or other ballistics device is fired, accidentally or intentionally, the hose connected to that initiator and the unit being actuated, and all other components subjected to gases are replaced. The general condition of the hoses are checked on the periodic aircraft inspections.

Overaged or damaged initiators should be disposed of in accordance with existing directives. Improper disposal could result in serious injury to personnel not familiar with such explosive devices.

When aircraft are being prepared for deployment for extended periods of time to areas where replacement cartridges/initiators are not readily available the expiration date of the various cartirdge-actuated devices of concern to the AME should be checked. Any items which would become overage during the deployment should be replaced prior to the actual deployment date.

Calendar inspection requirements for most canopy jettison systems will include an operational check or test of components and controls and a check for proper adjustment, locking, alignment, and sealing. The operational checkout should be accomplished in strict conformance to the steps provided in the Maintenance Instructions Manual and/or on the Maintenance Requirement Cards. Deviation from the step-by-step procedures or unauthorized shortcuts cannot be tolerated and could result in serious injury or death to personnel and/or costly damage to the aircraft.

If a canopy must be replaced with one that has not been adjusted for the specific aircraft, complete rigging and adjustment in accordance with the Maintenance Instructions Manual will be necessary. In most cases the canopy rollers, shims, wedges, locking hooks, and other similar miscellaneous hardware must be transferred from the old canopy to the new one.

The weight of many canopies will demand that a canopy sling and hoisting equipment be utilized in the removal and installation procedure. Insure that the correct sling is used and that the capacity of the hoisting equipment is adequate to handle the weight of the canopy. Necessary maneuvering of the canopy during removal and installation will require that stable and approved hoisting equipment be used.

Replacement of damaged panels in canopies and windshields is the responsibility of personnel in the AMS rating.

PNEUMATIC CANOPY SYSTEM

An example of a pneumatically operated canopy system is that incorporated in the McDonnell Aircraft Corporation's F-4 "Phantom II" jet fighter.

Description/Operation

The Phantom II canopy installation (fig. 9-1 (A)) is of the dual clamshell type. Each canopy is hinged at the aft end and is opened and closed by reciprocating movement of a pneumatic actuating cylinder attached near the rear of each canopy. Figure 9-7 is a modified schematic of the forward canopy actuation system.

The canopies are operated by three general types of controls. The normal controls actuate the canopy normal pneumatic system. The emergency controls actuate the canopy emergency pneumatic system and are used only for inflight escape or crash rescue. Manual controls are provided for use only in the event of a canopy normal pneumatic system failure.

CANOPY NORMAL PNEUMATIC SYSTEM.—Air at 3,000 psi is supplied from the aircraft pneumatic system and is reduced to 1,000 psi by a pressure regulator in the canopy pneumatic system. A relief valve is incorporated for protection of the normal system in case of pressure regulator failure or, when the aircraft is shut down, in case of thermal expansion. Whenever the canopy actuators are closed, pneumatic pressure is continually exerted in the actuators helping to hold the canopy closed.

The canopies are opened or closed by manually selecting a selector valve position by means of an internal selector lever or the external open and close push buttons. Selecting the valve to the OPEN position directs air pressure to the extend side of the canopy actuator. The canopy actuator is connected to the canopy locking and unlocking mechanism in such a way that when the actuator extends, initial extension action causes the actuator outer barrel to travel downward unlocking the canopy latches before the actuator piston extends to open the canopy. Even though air pressure remains on the retract (canopy closed) side of the actuator piston, it does not have sufficient working area to successfully resist movement of the piston and the canopy raises to the open position.

Selecting the valve to CLOSED merely dumps the open pressure completely out of the system and the air pressure on the retract side of the actuator piston is enabled to retract the piston, since there is no resistance to piston movement. One-way restrictors in the canopy open and close lines slow the operating time and prevent structural damage which could be caused by the canopy slamming open or closed. Final actuator retraction movement causes the locking mechanism to rotate and engage the canopy locks.

An amber CANOPY UNLOCK light is located in the forward and aft cockpits to notify the crew of an unlocked canopy condition. The forward cockpit mounted light will illuminate when either canopy is unlocked. The aft light will illuminate only when the aft canopy is unlocked. Either light being illuminated is reason for aborting a flight until the cause is corrected. If an unlock light illuminates, the canopy must not be opened by using the normal canopy open procedure until it has been determined that the canopy actuator shear pin has not been sheared. If the pin is sheared, normal opening pneumatic pressure could cause the actuator to puncture damage the canopy.

If canopy closure is attempted with engines running above a stabilized idle rpm the canopy may not lock due to back pressure caused by the aircraft pressurization system.

CANOPY EMERGENCY PNEUMATIC SYSTEM.—Jettison of the canopy is accomplished by the emergency pneumatic system. The emergency system is actuated in flight automatically as a part of the ejection sequence by pulling either the face curtain ejection handle or the secondary firing control. This action causes the firing of the seat mounted initiator (fig. 9-7). Pressure created by the firing of the initiator is routed through the aircraft's emergency escape sequencing system to operate the gas-pressure-operated valve. The function of the pressure-operated valve is to direct emergency air pressure from the storage bottle directly to the extend side of the canopy actuating cylinder and, at the same time, to trip the emergency dump valve which dumps all air pressure from the canopy CLOSE line. Emergency air pressure is also routed to the cockpit flooding doors. These doors open to reduce the time required to equalize the cockpit pressure under water if the aircraft ditches. The difference in cockpit pressure and water pressure against the outside of

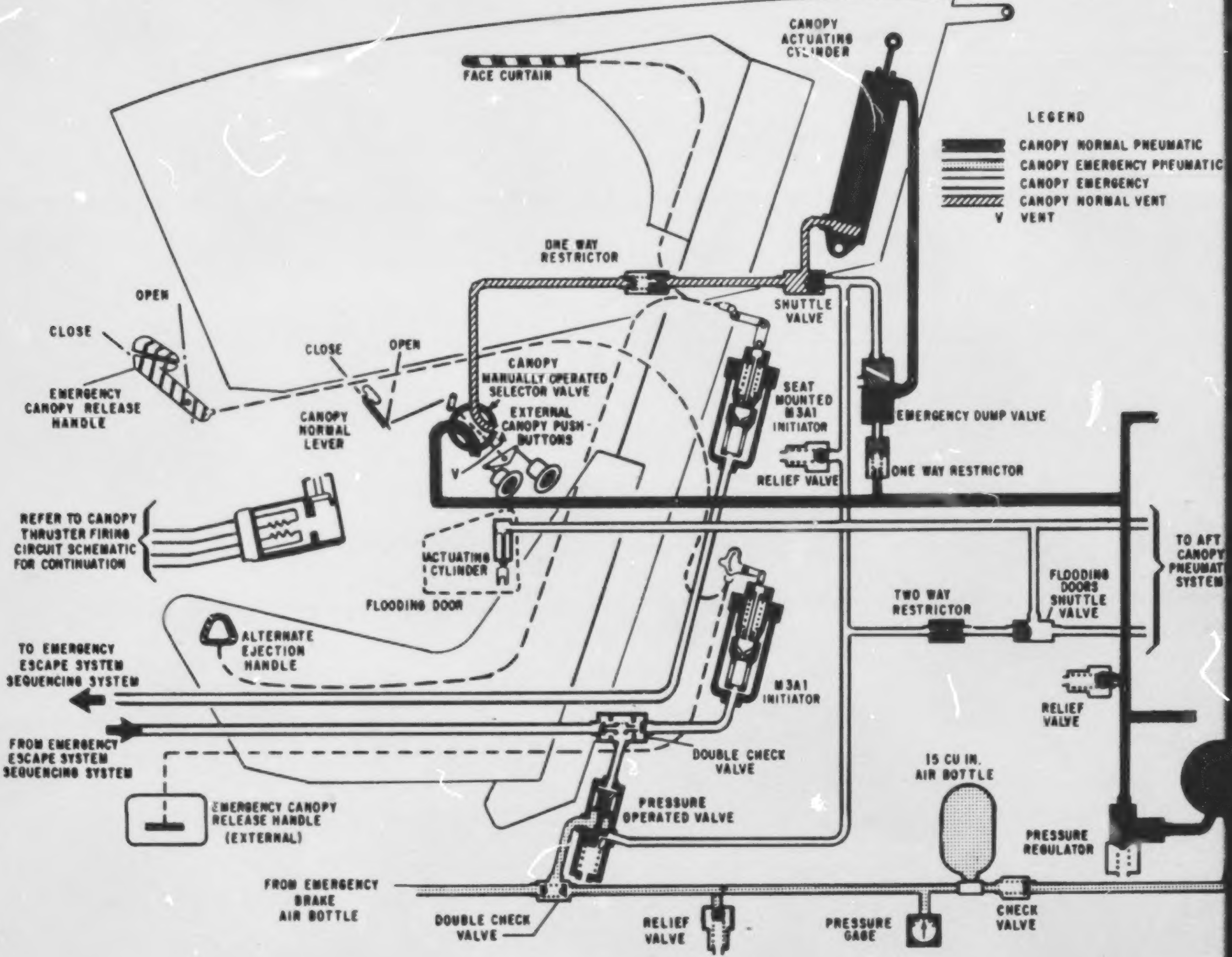

FACE CURTAIN
CANOPY ACTUATING CYLINDER
LEGEND
CANOPY NORMAL PNEUMATIC
CANOPY EMERGENCY PNEUMATIC
CANOPY EMERGENCY
CANOPY NORMAL VENT
V VENT
ONE WAY RESTRICTOR
SHUTTLE VALVE
OPEN
CLOSE
EMERGENCY CANOPY RELEASE HANDLE
CLOSE
OPEN
CANOPY MANUALLY OPERATED SELECTOR VALVE
CANOPY NORMAL LEVER
EXTERNAL CANOPY PUSH-BUTTONS
V
SEAT MOUNTED M3A1 INITIATOR
EMERGENCY DUMP VALVE
RELIEF VALVE
ONE WAY RESTRICTOR
REFER TO CANOPY THRUSTER FIRING CIRCUIT SCHEMATIC FOR CONTINUATION
ACTUATING CYLINDER
FLOODING DOOR
TO AFT CANOPY PNEUMAT SYSTEM
FLOODING DOORS SHUTTLE VALVE
TWO WAY RESTRICTOR
ALTERNATE EJECTION HANDLE
TO EMERGENCY ESCAPE SYSTEM SEQUENCING SYSTEM
M3A1 INITIATOR
RELIEF VALVE
FROM EMERGENCY ESCAPE SYSTEM SEQUENCING SYSTEM
DOUBLE CHECK VALVE
15 CU IN. AIR BOTTLE
EMERGENCY CANOPY RELEASE HANDLE (EXTERNAL)
PRESSURE OPERATED VALVE
PRESSURE REGULATOR
FROM EMERGENCY BRAKE AIR BOTTLE
DOUBLE CHECK VALVE
RELIEF VALVE
PRESSURE GAGE
CHECK VALVE

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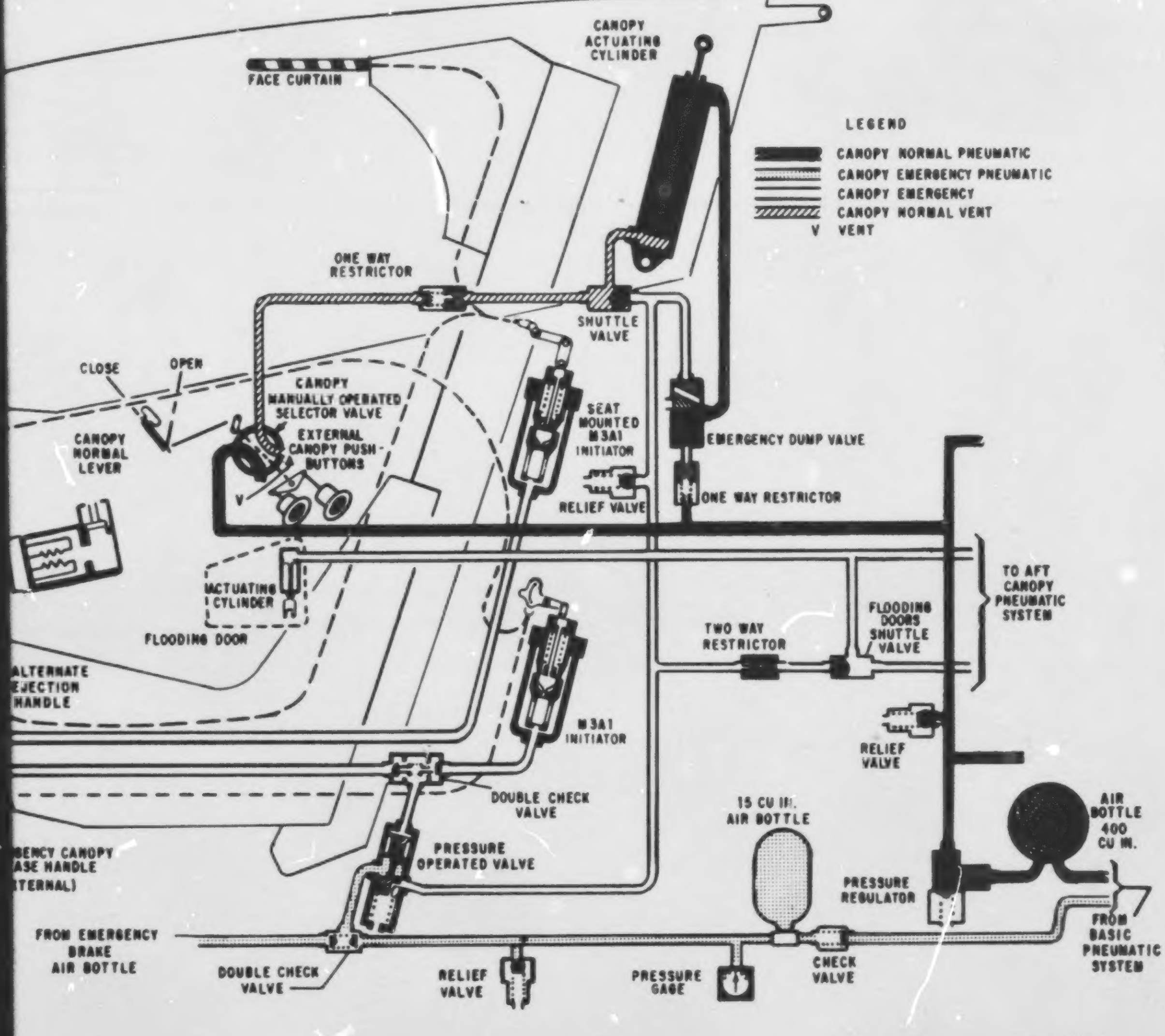
Figure 9-7.—F-4 canopy actuation system (forward-modified).


CANOPY ACTUATING CYLINDER
FACE CURTAIN
LEGEND
CANOPY NORMAL PNEUMATIC
CANOPY EMERGENCY PNEUMATIC
CANOPY EMERGENCY
CANOPY NORMAL VENT
V VENT
ONE WAY RESTRICTOR
SHUTTLE VALVE
CLOSE
OPEN
CANOPY MANUALLY OPERATED SELECTOR VALVE
CANOPY NORMAL LEVER
EXTERNAL CANOPY PUSH-BUTTONS
V
SEAT MOUNTED M3A1 INITIATOR
EMERGENCY DUMP VALVE
RELIEF VALVE
ONE WAY RESTRICTOR
ACTUATING CYLINDER
FLOODING DOOR
TO AFT CANOPY PNEUMATIC SYSTEM
TWO WAY RESTRICTOR
FLOODING DOORS SHUTTLE VALVE
ALTERNATE EJECTION HANDLE
M3A1 INITIATOR
RELIEF VALVE
DOUBLE CHECK VALVE
15 CU IN. AIR BOTTLE
AIR BOTTLE 400 CU IN.
GENCY CANOPY ASE HANDLE TERNAL)
PRESSURE OPERATED VALVE
PRESSURE REGULATOR
FROM EMERGENCY BRAKE AIR BOTTLE
DOUBLE CHECK VALVE
RELIEF VALVE
PRESSURE GAGE
CHECK VALVE
FROM BASIC PNEUMATIC SYSTEM

AM.1176

Figure 9-7.—F-4 canopy actuation system (forward-modified).

the canopy could otherwise result in the canopy not opening after a water entry (ditching).

On the later version F-4 canopy system, illustrated in figure 9-7, the emergency brake air bottle provides an additional or secondary source of pneumatic pressure. A double check valve prevents pressure from flowing from the emergency brake bottle to the canopy emergency air bottle and vice versa.

The canopy thruster (fig. 9-7) provides an additional force to the forward canopy to insure canopy jettisoning when adverse airloads are applied to the forward canopy, which is the case when the aft canopy is jettisoned before the forward one. When the canopy jettison sequence is initiated, an arm on the canopy locking mechanism torque tube actuates a canopy thruster switch. The thruster cartridges are electrically fired and the resulting gas pressure forces the thruster piston to extend approximately two inches, contacting the canopy frame and forcing the canopy upward into the windstream.

The canopy mechanisms include three shearpins each—one in the canopy actuator rod ends and two in the canopy hinges. During emergency operation in flight, these shearpins fail as the canopy is opened into the wind blast existing outside the aircraft. The canopy is thus removed from the aircraft.

The emergency system may be actuated separately from the ejection sequence from either inside or outside the cockpit by means of emergency canopy release handles. These are for use in case of the necessity of crash escape or rescue or in the event automatic canopy jettisoning does not occur after pulling the face curtain and/or secondary firing control handle. The emergency escape sequencing system is utilized when canopy jettison is initiated by the face curtain or the secondary firing control as a part of the ejection seat sequence.

Firing of the aircraft structure mounted initiator by means of the internal or external emergency release handles routes initiator gas pressure directly from the initiator through the double check valve and the gas pressure operated valve to the canopy actuator and dump valve. The same sequence of events occurs as in the in-flight emergency canopy operation, except that when actuated on the ground there is no wind to carry away the canopy; therefore, it is merely pushed open and remains on the aircraft. In this case the canopy opens slightly faster than normal due to the higher pressures used in the emergency system.

When the external emergency jettison (release) handle is pulled, the forward canopy is jettisoned, and after the forward canopy has cleared the aft cockpit enclosure the aft canopy is jettisoned. This slight delay in jettisoning the aft enclosure is intended to prevent the possibility of the forward canopy landing in the unprotected aft cockpit.

CANOPY MANUAL CONTROL OPERATION.—The Phantom II is equipped with a manual canopy operation control for use on the ground when and if the canopy normal system should become inoperative due to loss of pressure. The mechanical arrangement of the components varies between the front and rear seats. However, the operation of the canopy manual controls in either cockpit or outside the fuselage serves to unlock the canopy from its normal latches in either case. Then, when the normal handle is placed in the open position, the canopy may be pushed open manually. The normal handle in the open position allows the closed side of the actuator to be vented and thereby releases trapped air pressure. The canopy must be held open when entering or leaving the cockpit after a manual opening, since without pressure, the actuator may not hold the canopy in the open position.

Maintenance

Organizational maintenance on the F-4 canopy system is generally limited to inspection, modification, operational checkouts, trouble analysis, replacement and adjustment of system components and linkage, and lubrication.

Checkout procedures for the system are provided in the aircraft Maintenance Instructions Manual and Maintenance Requirements Cards. The items to be checked and the frequencies at which these checks are to be conducted are established by the applicable Maintenance Requirements Information Cards or the Periodic Maintenance Requirements Manual.

CAUTION: Always insure that ejection seat and canopy safety pins are installed prior to working or entering the cockpit area to prevent inadvertent firing.

A complete checkout of the canopy system includes an operational and functional check of the canopy opening and closing system, emergency pneumatic system checkout, jettison controls checkout, manual unlocking handles checkout, and a canopy shear pins checkout. Personnel in the AE rating will perform a checkout of the canopy thruster firing circuit and the canopy unlock warning circuit.

A variety of special tools and equipment such as push-pull type spring scales, safety struts, lock clearance probe, rigging tools, canopy and ejection seat mechanism tester, etc., are necessary to accomplish the various checkouts. For example: The push-pull type spring scale is used to check the force required to manually unlock the canopy; the canopy and ejection seat mechanism tester is used to perform the functional test of the emergency pneumatic system; and a stop watch is necessary to check the canopy opening and closing times. The use of the correct canopy safety strut and strict adherence to the step-by-step procedures provided in the MIM or Maintenance Requirements Card decks cannot be overemphasized. Failure to follow these detailed procedures could result in serious injury to personnel and damage to very expensive equipment.

Unscheduled maintenance of the canopy system includes such maintenance tasks as troubleshooting, adjusting or rigging, repair, and removal and replacement of components. Troubleshooting system malfunctions should be accomplished by well qualified personnel who possess a thorough knowledge of the system.

With a thorough knowledge of the system, a careful examination of the facts concerning the malfunction and reference to the troubleshooting aids provided in the applicable MIM should result in a quick determination of the probable cause and finally, through logical reasoning, the exact cause of malfunction. Repair or correction of the malfunction in accordance with the procedures provided in the MIM is followed by another operational check to insure that the malfunction has been corrected and the system operates properly in all modes.

Intermediate maintenance repair of canopy system components consists of disassembly, cleaning, inspection, repair, assembly, and testing in accordance with the instructions provided in the MIM or the applicable 03 series overhaul manual.

Repair actions on components are documented on the appropriate copies of the Maintenance Action Forms (MAF's). When modifications are required on components as a result of a technical directive, the maintenance action is recorded on a Technical Directive Compliance Form.

When components are forwarded from one level of maintenance to another level for repair or check and test, they must be properly handled to prevent unnecessary damage. All ports of pneumatic devices should be plugged to prevent the entry of contamination. Parts should be cleaned, preserved, and packaged as necessary to prevent damage from handling, shipping, and storage. Items going from a supported activity to a local Intermediate support activity for immediate repair or check and test will be packaged and preserved in accordance with local procedures established by the AIMD.

HYDRAULIC CANOPY SYSTEM

An example of a hydraulically operated canopy system is that incorporated in the Grumman Aircraft Engineering Corporation's A-6A attack bomber.

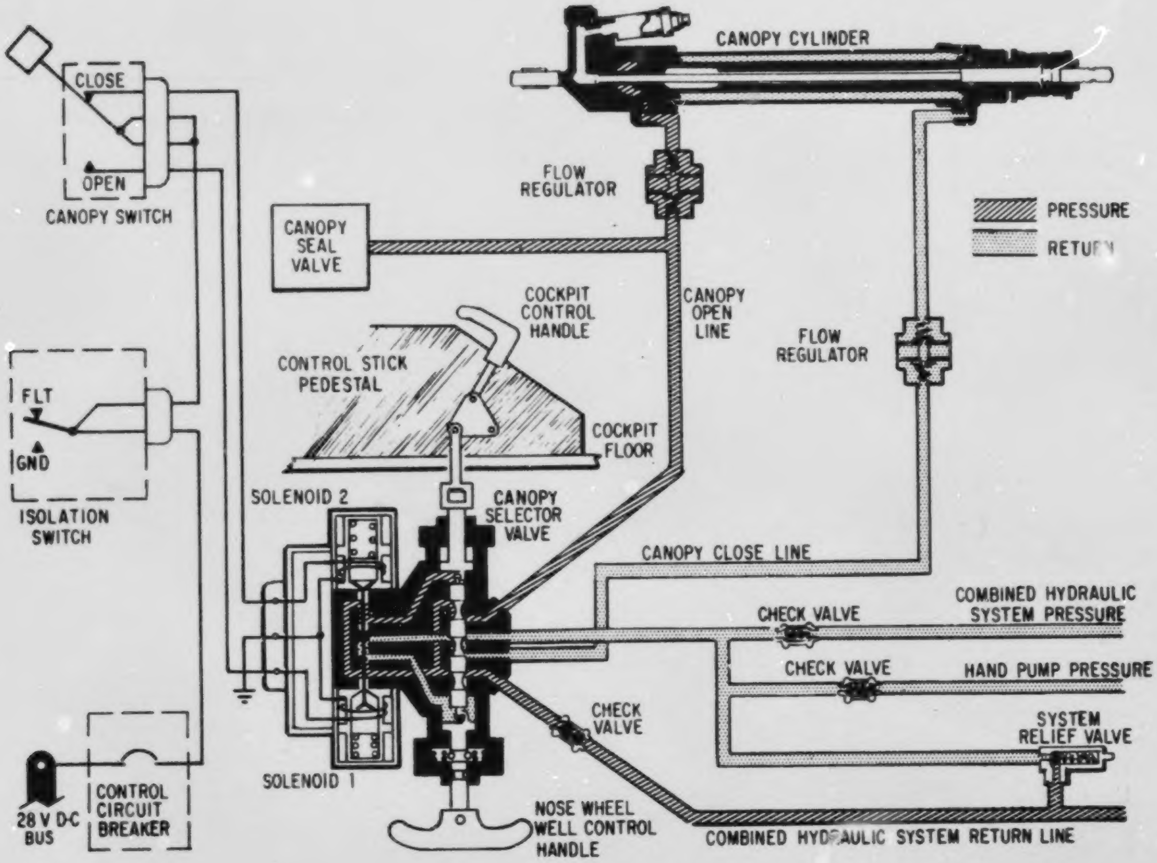
Description/Operation

In the A-6A the cockpit is covered by a jettisonable sliding canopy that is powered by the canopy system. The canopy system consists of the components required for normal operation and emergency jettison of the canopy. The entire system is hydraulically operated with the exception of the jettison device. Earlier versions of the A-6A incorporate an electrical jettison while later versions employ the pneumatic jettison concept. Hydraulic power for operation of the system is furnished by the combined hydraulic system or the hand pump system. (See fig. 9-8.)

Hydraulic flow to open or close the canopy is controlled through a selector valve which is in the nosewheel well under the cockpit floor. This selector valve may be operated either electrically or manually. Normally operation is electrical through the CANOPY switch on the pilot's instrument panel. This switch controls the selector valve whenever the engines are operating or whenever external electrical and hydraulic power are applied to the aircraft.

The hand pump system can be used to manually pump the canopy into position when combined hydraulic system power is not available on the aircraft. The hand pump is in the nosewheel well and can be operated either from there or from the cockpit. The canopy selector valve can also be manually actuated either from the cockpit or nosewheel well.

Whenever the selector valve is selected to the closed position, hydraulic pressure from either the combined (both engines) hydraulic


CANOPY CYLINDER
CLOSE
OPEN
CANOPY SWITCH
FLOW REGULATOR
CANOPY SEAL VALVE
PRESSURE
RETURN
COCKPIT CONTROL HANDLE
CANOPY OPEN LINE
FLOW REGULATOR
CONTROL STICK PEDESTAL
FLT
GND
COCKPIT FLOOR
ISOLATION SWITCH
SOLENOID 2
CANOPY SELECTOR VALVE
CANOPY CLOSE LINE
COMBINED HYDRAULIC SYSTEM PRESSURE
CHECK VALVE
CHECK VALVE
HAND PUMP PRESSURE
CHECK VALVE
SYSTEM RELIEF VALVE
SOLENOID 1
CONTROL CIRCUIT BREAKER
28 V D-C BUS
NOSE WHEEL WELL CONTROL HANDLE
COMBINED HYDRAULIC SYSTEM RETURN LINE

AM.145

Figure 9-8.—Hydraulic canopy operation schematic.

system or the hand pump system flows through the selector valve into the canopy close line. Pressure in this line is delivered through a flow regulator to the rod end of the canopy actuating cylinder, causing the piston and rod to retract and close the canopy. Opening of the canopy is the reverse of the closing operation.

NOTE: Maintenance of the hydraulic portion of the A-6A canopy actuation system is the responsibility of the AMH rating.

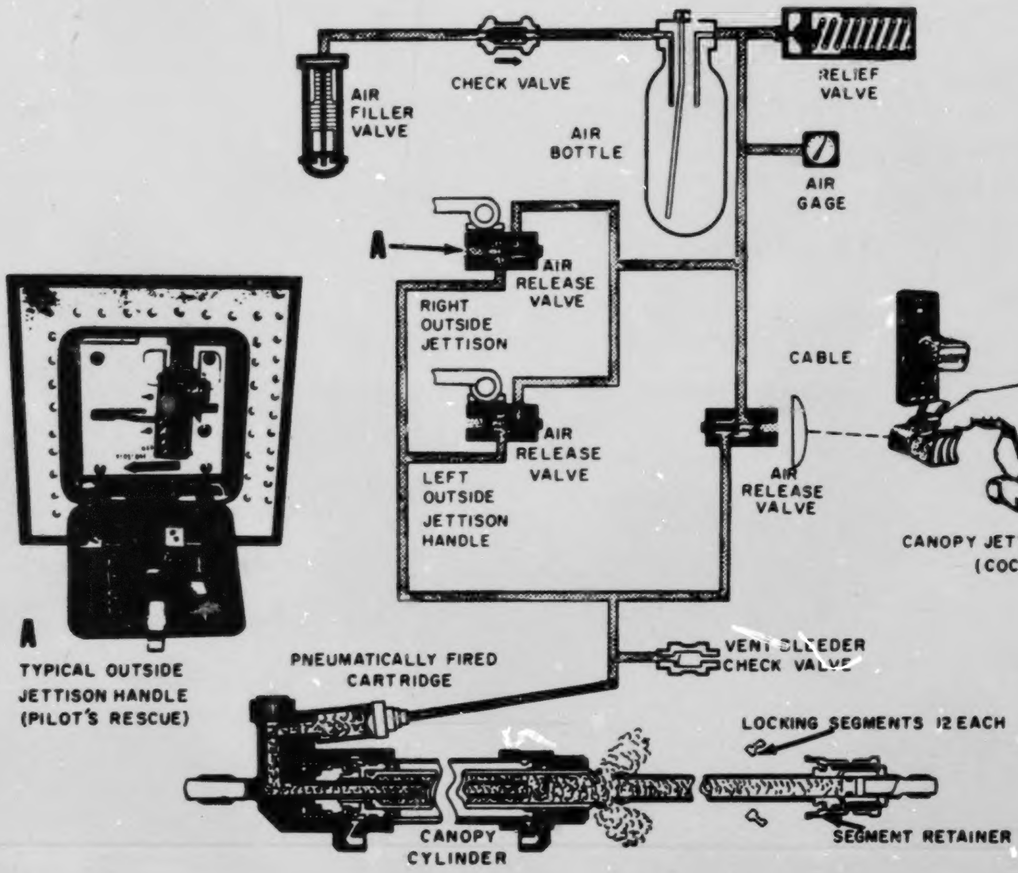
In an emergency the sliding canopy is jettisoned by a mechanism which operates in much the same manner as the T-2A clamshell type. However, unlike the T-2A system, the A-6A canopy jettisoning system is not actuated as part of the ejection sequence, but must be manually selected separately from the ejection seats. The canopy ejection is a separate function because the normal procedures for utilizing the ejection seat require ejection through the canopy unless special conditions dictate a deviation is necessary. It will be recalled that the actuator (screwjack) also houses a remover tube which contains an air charge. In the A-6A scheme a jettison sleeve is housed in the canopy actuator rod. Instead of a compressed air charge stored inside the rod, passages connect to a jettison cartridge mounted on the side of the cylinder-head end. When the cartridge is fired, expanding gases create the necessary pressure to unlock the jettison sleeve from the rod end and force it and the canopy aft and off the aircraft.

As mentioned previously, the original A-6A design provided for electrical jettison initiation. In this configuration the cartridge is electrically fired by selecting JETTISON on any one of three jettison switches, one in the cockpit and two outside the fuselage on either side of the aircraft.

In the later pneumatic configuration illustrated in figure 9-9, the jettison cartridge is fired by pneumatic pressure from a small (14.6 cu in.) air bottle pressured with nitrogen to 2,450 psi at 70° F prior to takeoff. Three air release valves are installed in the aircraft for jettisoning the canopy: one is actuated from the cockpit; the other two by their respective RESCUE handle on the engine intake air ducts.

Opening any one of the three air release valves directs nitrogen pressure from the bottle to the canopy actuator cap assembly and fires the pneumatic jettison cartridge.

Manual release of the hydraulic cylinder from the canopy attachment is accomplished by pulling the manual release handles located under two access doors on the aft end of the canopy shell or the single manual release handle located on the canopy overhead center beam.


AIR FILLER VALVE
CHECK VALVE
AIR BOTTLE
RELIEF VALVE
AIR GAGE
A
AIR RELEASE VALVE
RIGHT OUTSIDE JETTISON
AIR RELEASE VALVE
LEFT OUTSIDE JETTISON HANDLE
CABLE
AIR RELEASE VALVE
CANOPY JETTISON HANDLE (COCKPIT)
A
TYPICAL OUTSIDE JETTISON HANDLE (PILOT'S RESCUE)
PNEUMATICALLY FIRED CARTRIDGE
VENT BLEEDER CHECK VALVE
LOCKING SEGMENTS 12 EACH
CANOPY CYLINDER
SEGMENT RETAINER

AM.1177

Figure 9-9.—Canopy jettison schematic.

Components

The main components of the jettison system are illustrated in figure 9-9. The relief valve prevents excessive air bottle pressure increases due to thermal expansion and overpressurization during charging. The valve cracks to relieve pressure at 3,800 psi and reseats at 3,400 psi.

The air gage provides a means of checking proper system precharge. It is tapped in the pressure line between the air bottle and the cockpit air release valve.

The vent bleeder valve is located on the forward side of the left boarding ladder well. It is located downstream of all three air release valves and vents any low-pressure nitrogen that may have leaked past the air release valves, thus preventing inadvertent cartridge actuation. The valve is normally open at 40 to 80 psi and when an air release valve is actuated, the bleeder valve closes and remains closed throughout the jettison operation. The valve will reopen when the pressure in the system is reduced below 40 psi. The bleeder valve also has a manual override that permits bleedoff of nitrogen pressure after testing the performance of the jettison system as required during periodic inspections.

The canopy actuating and jettisioning cylinder is primarily the concern of personnel in the AMH rating; however, the cylinder can become damaged during canopy removal and installation if the exact procedures provided in the MIM are not strictly adhered to.

Maintenance

Maintenance of the A-6A canopy and canopy jettison system, illustrated in figures 9-8 and 9-9, includes removal and installation of the canopy and system components, lubrication, rigging and adjustment, and periodic inspection.

Prior to performing any maintenance insure that the ejection seat and canopy safety pins are installed and that the canopy switches or control handles correspond with the canopy position. On later model A-6 aircraft the canopy selector valve is spring loaded to the neutral position and movement of the canopy requires that the switch or control handle be held in the open or closed position in order to produce canopy movement. In any case, stay out of the path of canopy travel during canopy operation. Do not operate a system that you are not thoroughly familiar with and qualified to operate.

Rigging and adjustment of the canopy is accomplished by adjusting the end terminal of the actuating cylinder so that the cylinder ball locks lock under a given hydraulic pressure preload and this adjustment is accomplished by personnel in the AMH rating.

The size and weight of the canopy requires that a hoisting sling be used in removal and installation. When removing the canopy to accommodate cockpit working space or the removal of cockpit equipment, a special canopy adapter is available to position the canopy on top of the fuselage rather than lowering it completely off the aircraft. Once on the adapter, the canopy should be immediately secured with the attached nylon straps. Use of the adapter on the flight deck or other outside areas that could be exposed to high wind conditions, such as jet or propeller blasts, is prohibited.

If manual removal of the canopy becomes necessary in order to get the canopy open due to a malfunction of the normal hydraulic opening and closing system, the canopy seal must be deflated. The seal can normally be deflated by cracking the canopy slightly open with the hydraulic hand pump or the electric-motor-driven auxiliary hydraulic pump. Should such action fail to deflate the seal, the seal can be cut with a knife. Cutouts are provided in the seal retainer to accommodate cutting of the seal from either inside or outside of the cockpit.

After the canopy has been disconnected from the actuator's piston end terminal, the extended piston rod will rest on the forward edge of the fuselage panel directly beneath it. If the piston is retracted without lifting the terminal end, it may catch on the panel and cause the locking segments (fig. 9-9) to fall out, leaving the cylinder in an unsafe condition. Loss of the segments could lead to accidental separation of the piston jettison sleeve and the piston rod of the actuating cylinder during flight with possible loss of the canopy during flight. Following proper MIM installation procedures for the canopy will preclude this possibility.

During periodic maintenance of the canopy jettison system and removal and installation of the actuator, the jettison cartridge must be removed and properly stowed so as not to present a hazard. New cartridges are supplied in protective hermetically sealed containers. When being replaced, an entry must be made in the aircraft logbook by personnel in the AZ rating, indicating the date of cartridge expiration, installation date, and lot number. Service life of the cartridge is the same as that prescribed for the T-2A initiator cartridges.

When installing a new cartridge the service life expiration date should be marked on the side of the cartridge in indelible ink. Also write the same information on the controlling maintenance document (MAF) so that it can be properly recorded in the aircraft logbook.

A light film of corrosion prohibiting oil may be applied to the cartridge prior to installation. In all cases conform to the type of lubricant and installation procedures prescribed in the MIM.

As previously stated, the operational check of the jettison system must always rigidly conform to the step-by-step procedures supplied in the applicable MIM with special consideration for the specific safety precautions peculiar to the system. If all air release handles and controls are not returned to their normal positions and the jettison system pressure bled off, the canopy could be accidentally jettisoned when it is being serviced and returned to a flight ready condition.

Disassembly, cleaning, inspection, repair, reassembly, and testing of components are normally accomplished at the Intermediate level maintenance activity in accordance with the component repair section of the applicable MIM. All maintenance should be performed by qualified personnel with appropriate quality assurance inspection at the steps specified in the MIM.

SEAT EJECTION SYSTEMS

The modern high-performance aircraft used by the Navy today make extreme demands of emergency escape devices. It has been a known fact for a long time that the most critical time for ejection from aircraft is at low altitudes, especially on takeoffs and landings. The ultimate in seat reliability, and the goal to which engineers have been working, is one that safely ejects the occupant at zero airspeed and at zero altitude or at low altitudes under high sink rate and/or adverse attitude conditions.

The Martin-Baker H-7, the Martin-Baker MK-GRU-7, ESCAPAC-1-C3 and the North American LS-1 ejection systems are discussed in this chapter.

MARTIN-BAKER EJECTION SEAT (MK H-7)

There are several variations of the Martin-Baker ejection seats. Each variation was developed to fulfill requirements by the individual aircraft manufacturers for the aircraft they produce. Typical of such variations is the MK-H-7 rocket ejection seat installed in the F-4. This seat has been modified by AFC 307 to provide a rocket pack and an ejection sequencing system. Several of the components have been changed to give the seat improved performance.

Description

The rocket assist ejection seat assembly illustrated in figures 9-10 (A) and (B) provides support and the necessary environmental equipment for the crewmembers during flight, and a means of fast, safe escape during emergency flight conditions. The seat assembly incorporates features permitting seat-man ejection at ground level, zero airspeed, as well as during emergency flight conditions. Associated emergency escape equipment, such as plumbing, gas fired initiators, and time delay sequence actuators are installed in the aircraft forward and aft cockpit areas which provide sequenced escape during dual ejection.

Basic components of the seat assembly include a catapult gun, a gas powered inertia reel, a rocket motor, and a personnel parachute. One percussion fired primary cartridge and two gas fired auxiliary cartridges in the catapult gun provide the initial forces required to eject the seat from the cockpit. Gas fired solid propellant grain in the rocket motor creates additional thrust during the ejection sequence, catapulting seat and occupant to a safe recovery altitude.

The gas powered inertia reel automatically prevents rapid forward movement of the seat occupant during deceleration crash forces or violent maneuvers, and positions and restrains the occupant's upper torso during the ejection sequence. After ejection, the personnel parachute is automatically deployed, separating the occupant from the seat for a safe descent.

Two separate control handles are provided on the seat to initiate the ejection sequence. The face curtain handle, located above the crewmember's head, is the primary control. This handle is attached to the face curtain, which furnishes face protection during ejection.

The secondary ejection handle, located between the crewmember's knees on the seat bucket, is the alternate control if the face curtain handle cannot be reached. Either control handle actuates the various linkage required to initiate the ejection sequence.

The seat is linked to the canopy by an interlock mechanism located on the top aft section of the seat to prevent ejection through the canopy. A block inserted in the seat interlock mechanism and attached to the canopy is pulled from the seat by the connecting cable during canopy jettison. Removal of the block allows the seat firing mechanism to rotate forward and initiate firing of the catapult gun.

The canopy interlock block is also linked to a safety pin which is inserted through the sear of the catapult firing mechanism. The safety pin remains installed during flight to protect the firing mechanism from inadvertent operation and is automatically withdrawn upon canopy separation.

Mounted on each side of the seat near the top are the drogue gun and time release mechanism. Automatic operation of the seat system after initial ejection is dependent upon these two units. Trip rods attached to anchor brackets pull the sears from these two units during upward travel of the seat, thus actuating the operating mechanism of each unit. The drogue gun deploys the drogue parachutes, which stabilize the seat. The time release mechanism is an automatic device that primarily regulates the opening of the personnel parachute at a predetermined altitude that is within a safe limit for the occupant.

The lower section of the seat assembly is comprised of a removable seat bucket assembly. The seat bucket rides in guide tracks on the main beams and is the only portion of the seat that moves to adjust to height of the occupant. Seat height adjustment is accomplished by an electrically operated actuator controlled by the seat height adjustment switch.

Seat bucket features include stowage for the survival kit; an emergency harness release handle that permits manual release of the occupant's harness during manual separation procedures; a shoulder harness manual control handle that permits manual locking and unlocking of the inertia reel, thereby controlling movement of the harness loop straps; a leg restraint manual release handle that permits manual release of the leg restraint cord lockpins; and two finger rings that permit manual adjustment of the leg restraint cords.

Normal Operation

Normal operation of the seat consists of controlling shoulder movement, seat bucket positioning, leg restraint cord adjustment, and manual release of the leg restraint cords.

Shoulder movement is controlled by positioning of the shoulder harness manual control handle. Mechanical linkage between the handle and gas powered inertia reel permits manual locking and release of the reel. Two harness loop straps on the reel extend and retract, allowing normal movement of the seat occupant.

Rapid, forward shoulder movement is automatically prevented by the inertia reel when the aircraft is subjected to forces that tend to pitch the seat occupant forward; such as, longitudinal crash forces or violent maneuvers. When forward motion of the seat occupant causes the harness loop straps to unwind from the inertia reel faster than a safe predetermined rate of speed, the inertia reel lock mechanism senses the excessive strap velocity and automatically locks the reel.

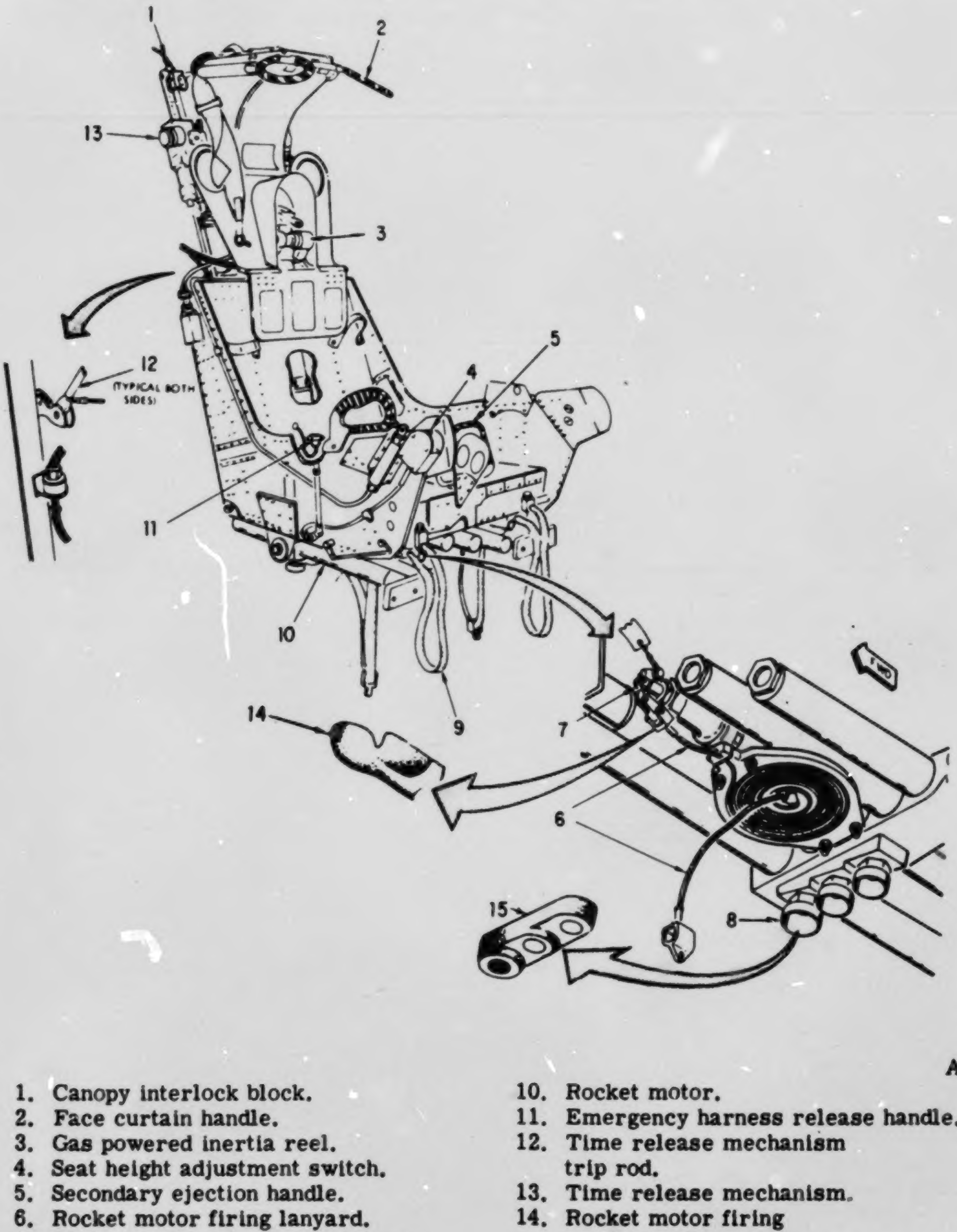
Seat bucket positioning is controlled by actuating the seat height adjustment switch. Seat bucket up and down travel is limited by limit switches located within the seat bucket positioning actuator.

Leg restraint cord adjustment is controlled by the leg restraint snubber box finger rings. When pulled forward, these rings allow the leg restraint cords to be pulled through the snubbing boxes of the seat, thus providing cord length as desired. Manual release of the leg restraint cords is controlled by the leg restraint manual release handle. When pulled aft, this handle causes mechanical linkage to release the leg restraint cord lockpins from the seat locking mechanisms, thereby releasing the occupant's legs from the seat.

Emergency Operation

The emergency escape sequencing system is a pyrotechnic system interconnecting the seat and canopy systems to provide sequenced canopy jettison and seat ejection during emergency egress of both crewmembers. Single ejection capability is also provided for the aft cockpit crewmember. Ejection is always dual when initiated from the forward cockpit (unless the aft crewmember has previously ejected).

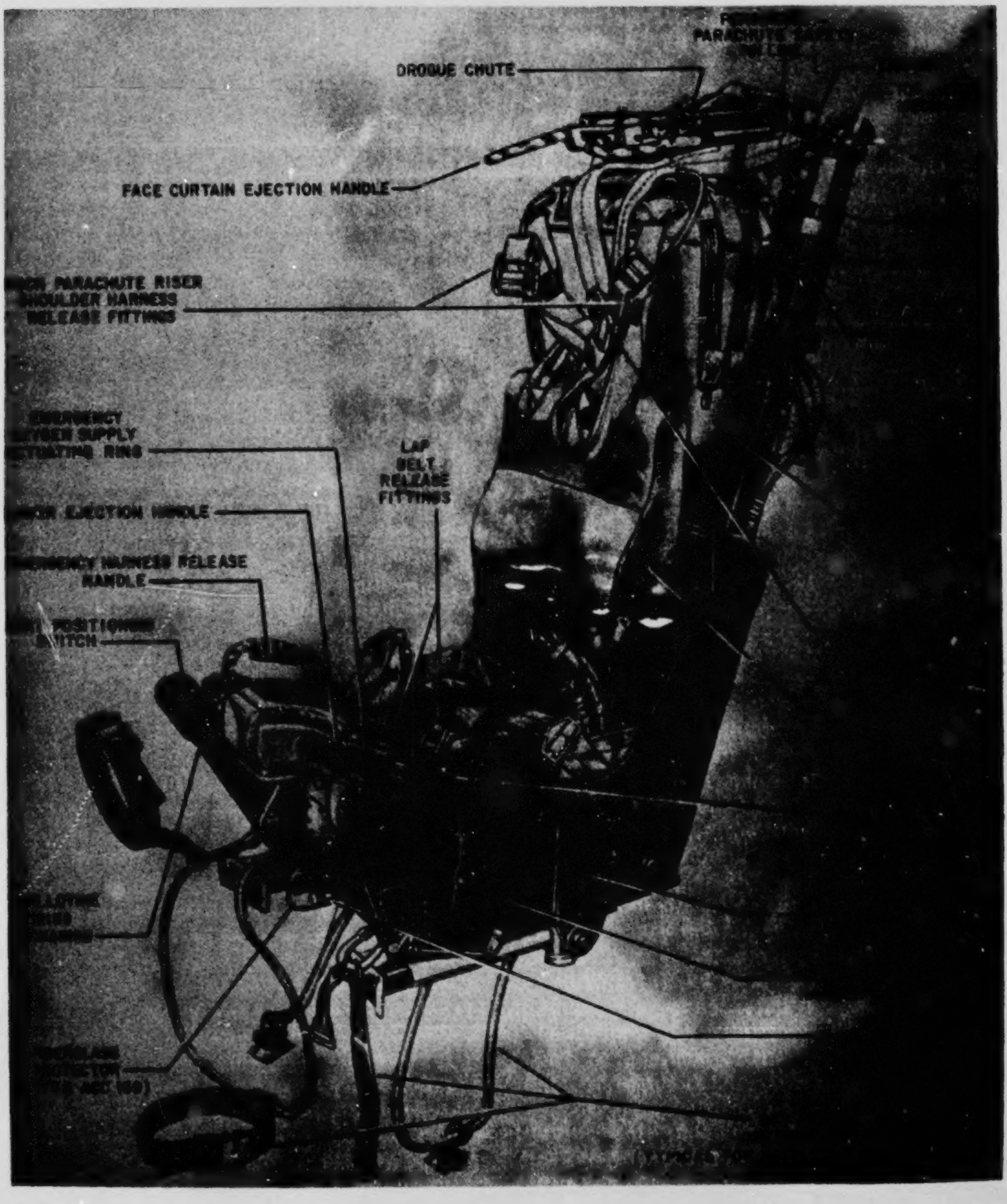
When an ejection is initiated, gas pressure generated by pyrotechnic initiators is routed through lines and hoses to the various seat and canopy components employed during ejection. The portion of the system that transfers gas pressure from the forward cockpit to the aft



AM.146

1. Canopy interlock block.
2. Face curtain handle.
3. Gas powered inertia reel.
4. Seat height adjustment switch.
5. Secondary ejection handle.
6. Rocket motor firing lanyard.
7. Rocket motor firing mechanism.
8. Manifold nozzles.
9. Leg restraint cord.
10. Rocket motor.
11. Emergency harness release handle.
12. Time release mechanism trip rod.
13. Time release mechanism.
14. Rocket motor firing mechanism cover.
15. Rocket nozzles protective cover.

Figure 9-10.—Rocket assist ejection seat (Martin-Baker). (A) Right side.


PARACHUTE
DROGUE CHUTE
FACE CURTAIN EJECTION HANDLE
PARACHUTE RISER
SHOULDER HARNESS
RELEASE FITTINGS
EMERGENCY
OXYGEN SUPPLY
ACTUATING RING
LAP
BELT
RELEASE
FITTINGS
EJECTION HANDLE
HARNESS RELEASE
HANDLE
POSITIONING
SWITCH

AM.146

Figure 9-10.—Rocket assist ejection seat (Martin-Baker). (B) Left side.

cockpit is dual, with two lines and initiators being used. One line and initiator serves as a backup should the other line become damaged or the initiator fails. Through the use of time delayed initiators and actuators, the aft seat is sequenced to eject first during a dual ejection. A schematic of the sequencing system used in the F-4J is provided in figure 9-11.

An eject command selector valve located in the aft cockpit allows the aft crewmember to select and initiate either a single ejection (aft seat only) or a dual ejection. With the valve handle in the normal (closed) position, the aft seat only will eject (single ejection) when initiated by the aft crewmember. The valve is in the normal position when the handle is vertical and flush with the valve body. To select dual ejection, the handle must be pulled out approximately 1 inch and turned clockwise 90°(open position). (See fig. 9-12 for open and closed position.) A dual ejection will always occur when initiated from the forward cockpit regardless of valve position.

Operation of the emergency escape sequencing system consists of three modes—forward cockpit initiated (dual) ejection, aft cockpit initiated dual ejection, and aft cockpit initiated single ejection.

FORWARD COCKPIT INITIATED DUAL EJECTION.—Ejection is always dual when initiated from the forward cockpit (unless the aft crewmember has previously ejected). The dual ejection sequence is initiated whenever the pilot pulls either the face curtain handle or the secondary ejection handle firing the forward mounted initiator.

Gas pressure from the seat mounted initiator is routed to the sequencing system stowing the aft cockpit equipment and operating the forward seat inertia reel, aft seat inertia reel, aft canopy pressure operated valve (opening flooding doors and jettisoning canopy), aft pressure operated sequence actuator (ejecting aft seat), forward canopy pressure operated valve (jettisoning forward canopy), and forward pressure operated sequence actuator (ejecting forward seat) (in that order).

AFT COCKPIT INITIATED DUAL EJECTION.—The aft crewmember initiates a dual ejection by opening the eject command selector valve and pulling either the face curtain handle or the secondary ejection handle, firing the seat mounted initiator. Gas pressure generated by the initiator is routed to the sequencing system, which operates the aft seat inertia reel, aft canopy pressure operated valve (opening the flooding doors and jettisoning the aft canopy), cockpit equipment stowage system, forward seat inertia reel, aft pressure operated sequence actuator (ejecting aft seat), forward canopy pressure operated valve (jettisoning forward canopy), and forward pressure operated sequence actuator (ejecting forward seat) (in that order).

AFT COCKPIT INITIATED SINGLE EJECTION.—Single ejection occurs when the aft cockpit crewmember pulls either the face curtain handle or the secondary ejection handle with the eject command selector valve in the normal (closed) position. Gas pressure generated by the aft seat mounted initiator is routed to the sequencing system, which operates the aft seat inertia reel, cockpit equipment stowage system, and aft canopy pressure operated valve (opening the cockpit flooding doors and jettisoning the aft canopy) (in that order). The crewmember continues to pull the face curtain or the secondary ejection handle to eject the aft seat.

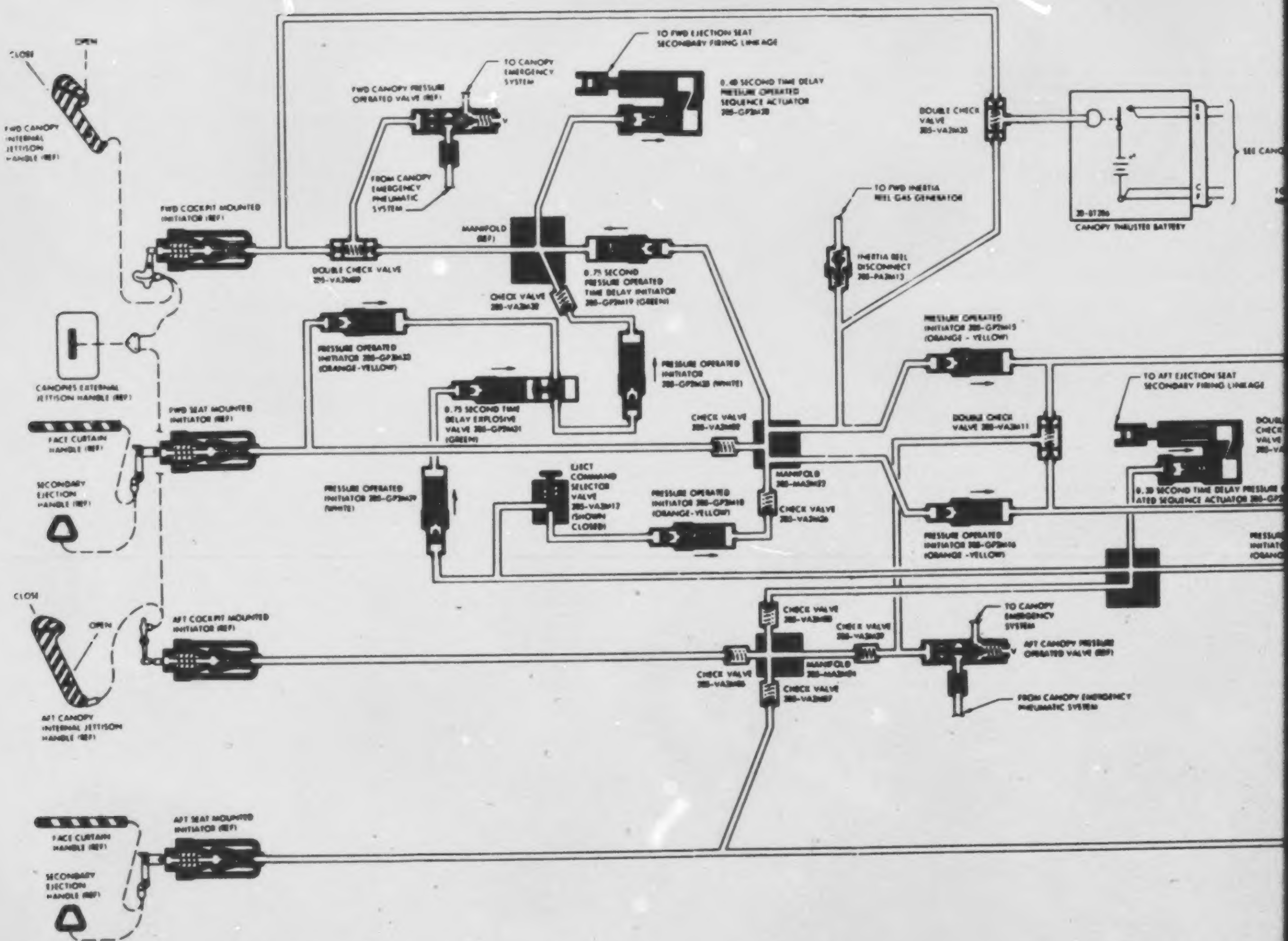
The forward crewmember may eject at any time after an aft cockpit single ejection by pulling either the face curtain handle or the secondary ejection handle, which will fire the forward seat mounted initiator and cause seat ejection.

If, after ejection (dual or single), automatic separation of seat and occupant does not occur due to malfunction of the seat mechanism, manual override of the seat mechanism by the occupant is necessary in order to accomplish a safe parachute descent. The emergency harness release handle must be pulled which releases all personnel restraints and personnel parachute restraints, and the occupant must then push free of the seat and manually pull the parachute D-ring. (See fig. 9-13.)

Ejection Sequence

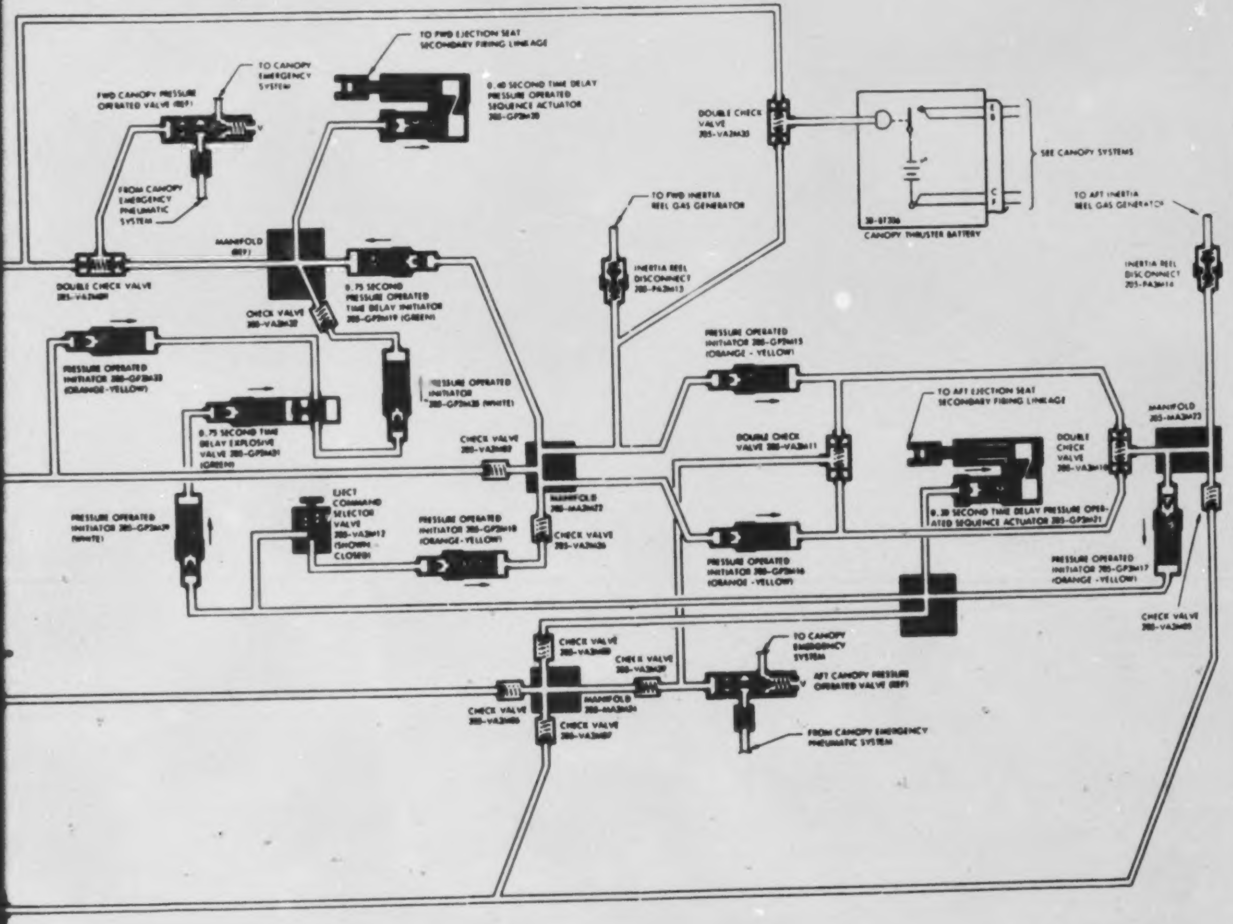
Ejection is accomplished by initially propelling the seat from the aircraft with a hot gas energized catapult gun with added thrust provided by an ignited solid propellant powered rocket motor attached to the seat.

In addition to high speed/high altitude ejection, the rocket thrust phase successfully accomplishes ejection at zero speed/zero altitude, permitting occupant and seat to be catapulted to a sufficient height, enabling full deployment of the parachute before returning to ground level.


CLOSE
OPEN
FWD CANOPY INTERNAL JETTISON HANDLE (REF)
TO CANOPY EMERGENCY SYSTEM
FWD CANOPY PRESSURE OPERATED VALVE (REF)
FROM CANOPY EMERGENCY PNEUMATIC SYSTEM
TO FWD EJECTION SEAT SECONDARY FIRING LINKAGE
0.40 SECOND TIME DELAY PRESSURE OPERATED SEQUENCE ACTUATOR 285-GP2M20
DOUBLE CHECK VALVE 285-VA2M35
CANOPY THRUSTER BATTERY
SEE CANO
FWD COCKPIT MOUNTED INITIATOR (REF)
DOUBLE CHECK VALVE 285-VA2M09
MANIFOLD (REF)
CHECK VALVE 285-VA2M30
0.75 SECOND PRESSURE OPERATED TIME DELAY INITIATOR 285-GP2M19 (GREEN)
TO FWD INERTIA REEL GAS GENERATOR
INERTIA REEL DISCONNECT 285-PA2M13
CANOPIES EXTERNAL JETTISON HANDLE (REF)
PRESSURE OPERATED INITIATOR 285-GP2M32 (ORANGE-YELLOW)
0.75 SECOND TIME DELAY EXPLOSIVE VALVE 285-GP2M31 (GREEN)
PRESSURE OPERATED INITIATOR 285-GP2M28 (WHITE)
PRESSURE OPERATED INITIATOR 285-GP2M15 (ORANGE - YELLOW)
TO AFT EJECTION SEAT SECONDARY FIRING LINKAGE
FWD SEAT MOUNTED INITIATOR (REF)
FACE CURTAIN HANDLE (REF)
SECONDARY EJECTION HANDLE (REF)
CHECK VALVE 285-VA2M02
DOUBLE CHECK VALVE 285-VA2M11
DOUBLE CHECK VALVE 285-VA
0.30 SECOND TIME DELAY PRESSURE OPERATED SEQUENCE ACTUATOR 285-GP
EJECT COMMAND SELECTOR VALVE 285-VA2M12 (SHOWN CLOSED)
PRESSURE OPERATED INITIATOR 285-GP2M29 (WHITE)
PRESSURE OPERATED INITIATOR 285-GP2M18 (ORANGE-YELLOW)
MANIFOLD 285-MA2M27
CHECK VALVE 285-VA2M26
PRESSURE OPERATED INITIATOR 285-GP2M16 (ORANGE -YELLOW)
PRESSURE INITIATO (ORANG
CLOSE
OPEN
AFT CANOPY INTERNAL JETTISON HANDLE (REF)
AFT COCKPIT MOUNTED INITIATOR (REF)
CHECK VALVE 285-VA2M08
CHECK VALVE 285-VA2M29
TO CANOPY EMERGENCY SYSTEM
AFT CANOPY PRESSURE OPERATED VALVE (REF)
CHECK VALVE 285-VA2M06
MANIFOLD 285-MA2M04
CHECK VALVE 285-VA2M07
FROM CANOPY EMERGENCY PNEUMATIC SYSTEM
AFT SEAT MOUNTED INITIATOR (REF)
FACE CURTAIN HANDLE (REF)
SECONDARY EJECTION HANDLE (REF)

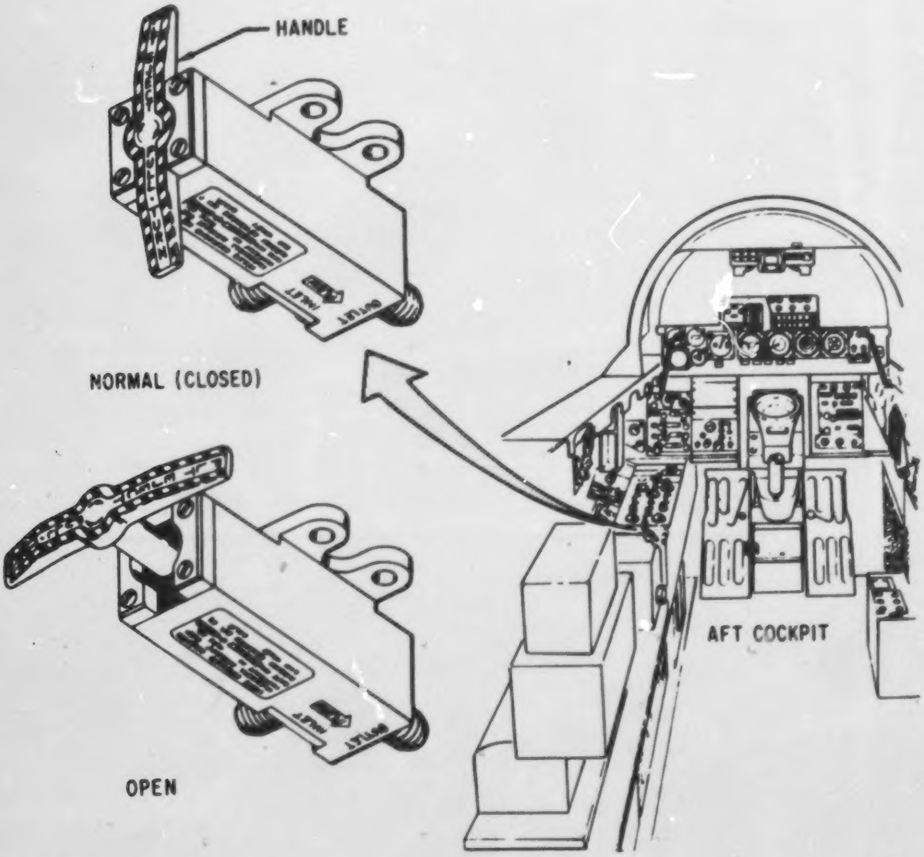
AM.117

Figure 9-11.—Emergency escape sequencing system schematic.


TO FWD EJECTION SEAT SECONDARY FIRING LINKAGE
TO CANOPY EMERGENCY SYSTEM
FWD CANOPY PRESSURE OPERATED VALVE (REF)
0.40 SECOND TIME DELAY PRESSURE OPERATED SEQUENCE ACTUATOR 205-GP2M20
FROM CANOPY EMERGENCY PNEUMATIC SYSTEM
DOUBLE CHECK VALVE 205-VA2M35
SEE CANOPY SYSTEMS
30-07306
CANOPY THRUSTER BATTERY
TO FWD INERTIA REEL GAS GENERATOR
TO AFT INERTIA REEL GAS GENERATOR
MANIFOLD (REF)
DOUBLE CHECK VALVE 205-VA2M09
0.75 SECOND PRESSURE OPERATED TIME DELAY INITIATOR 205-GP2M19 (GREEN)
CHECK VALVE 205-VA2M32
INERTIA REEL DISCONNECT 205-PA2M13
INERTIA REEL DISCONNECT 205-PA2M14
PRESSURE OPERATED INITIATOR 205-GP2M15 (ORANGE - YELLOW)
PRESSURE OPERATED INITIATOR 205-GP2M33 (ORANGE-YELLOW)
PRESSURE OPERATED INITIATOR 205-GP2M28 (WHITE)
TO AFT EJECTION SEAT SECONDARY FIRING LINKAGE
0.75 SECOND TIME DELAY EXPLOSIVE VALVE 205-GP2M31 (GREEN)
CHECK VALVE 205-VA2M07
DOUBLE CHECK VALVE 205-VA2M11
MANIFOLD 205-MA2M23
DOUBLE CHECK VALVE 205-VA2M10
MANIFOLD 205-MA2M22
PRESSURE OPERATED INITIATOR 205-GP2M29 (WHITE)
EJECT COMMAND SELECTOR VALVE 205-VA2M12 (SHOWN CLOSED)
PRESSURE OPERATED INITIATOR 205-GP2M18 (ORANGE-YELLOW)
CHECK VALVE 205-VA2M26
0.30 SECOND TIME DELAY PRESSURE OPERATED SEQUENCE ACTUATOR 205-GP2M21
PRESSURE OPERATED INITIATOR 205-GP2M16 (ORANGE -YELLOW)
PRESSURE OPERATED INITIATOR 205-GP2M17 (ORANGE -YELLOW)
CHECK VALVE 205-VA2M08
CHECK VALVE 205-VA2M05
CHECK VALVE 205-VA2M27
TO CANOPY EMERGENCY SYSTEM
AFT CANOPY PRESSURE OPERATED VALVE (REF)
CHECK VALVE 205-VA2M06
MANIFOLD 205-MA2M24
CHECK VALVE 205-VA2M07
FROM CANOPY EMERGENCY PNEUMATIC SYSTEM

AM.1178

Figure 9-11.—Emergency escape sequencing system schematic.



AM.1179

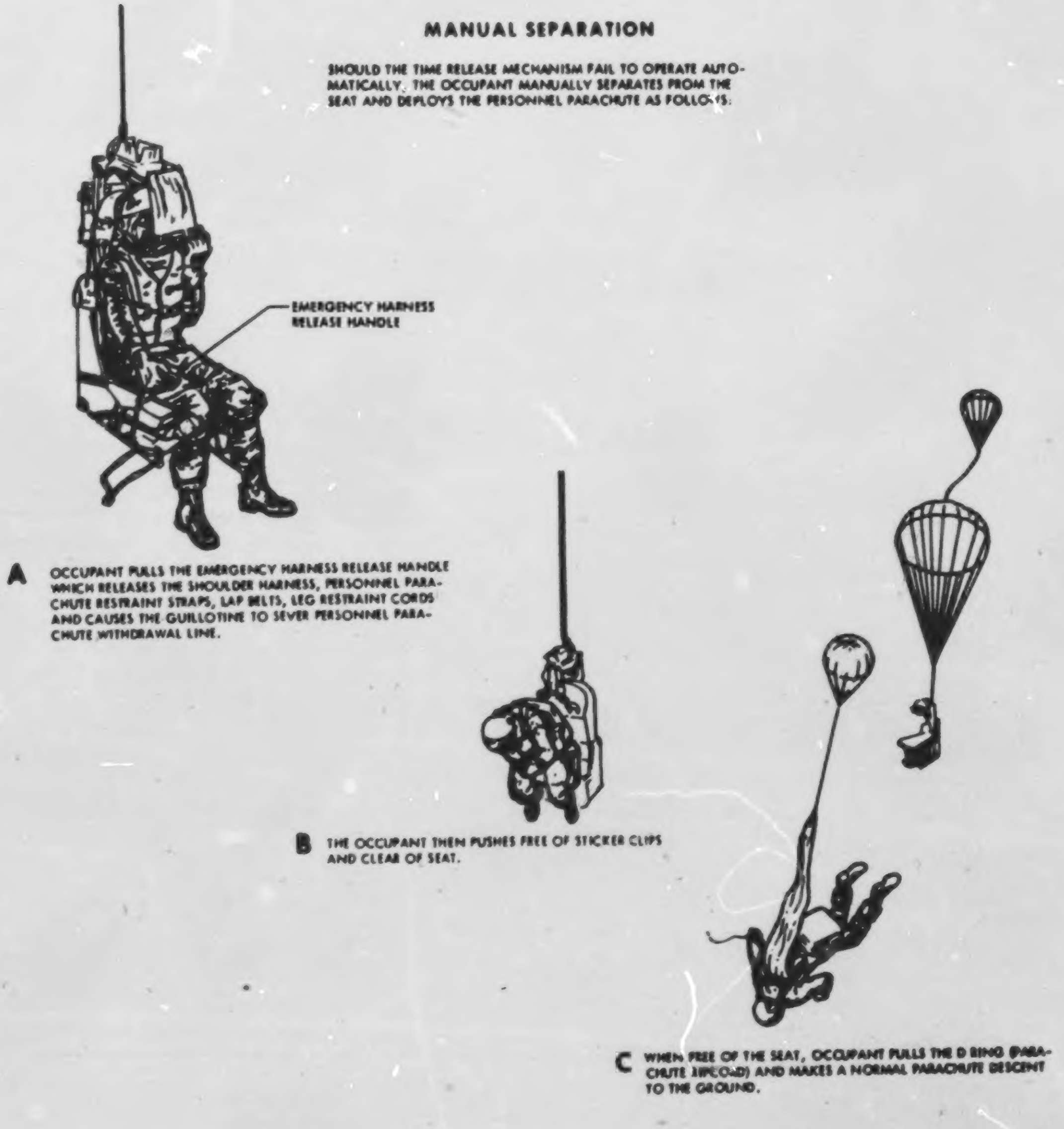
Figure 9-12.—Eject command selector valve.

Gas pressure created by the catapult gun primary cartridge causes the inner and intermediate barrels of the gun to extend upward. Upward travel of the inner barrel actuates the top latch mechanism, which unlocks the seat from the catapult gun outer barrel. Continued upward movement of the inner barrel propels the seat up the tracks of the catapult gun and fires the auxiliary cartridges as they become exposed to the hot propellant gases within the gun.

Gas pressure generated by the auxiliary cartridges add force to the gun during upward travel. Staggered firing of the catapult gun cartridges furnishes relatively even gas pressure within the gun during the power stroke, eliminating high acceleration forces during ejection.

During upward travel of the seat, trip rods pull the sears of the drogue gun and time release mechanism. The drogue gun time sequence is thereby initiated, and the time release mechanism now assumes an armed condition.

Subsequent actuation of the time release mechanism will occur provided the altitude is within safe limits for the seat occupant. Also, during upward travel of the seat, a lanyard attached to the rocket motor firing mechanism and secured to the cockpit floor is unwound, and when fully extended, pulls the sear of the rocket motor firing mechanism. Withdrawal of the sear


MANUAL SEPARATION
SHOULD THE TIME RELEASE MECHANISM FAIL TO OPERATE AUTOMATICALLY, THE OCCUPANT MANUALLY SEPARATES FROM THE SEAT AND DEPLOYS THE PERSONNEL PARACHUTE AS FOLLOWS:
EMERGENCY HARNESS RELEASE HANDLE
A OCCUPANT PULLS THE EMERGENCY HARNESS RELEASE HANDLE WHICH RELEASES THE SHOULDER HARNESS, PERSONNEL PARACHUTE RESTRAINT STRAPS, LAP BELTS, LEG RESTRAINT CORDS AND CAUSES THE GUILLOTINE TO SEVER PERSONNEL PARACHUTE WITHDRAWAL LINE.
B THE OCCUPANT THEN PUSHES FREE OF STICKER CLIPS AND CLEAR OF SEAT.
C WHEN FREE OF THE SEAT, OCCUPANT PULLS THE D RING (PARACHUTE RIPCORD) AND MAKES A NORMAL PARACHUTE DESCENT TO THE GROUND.

AM.1180

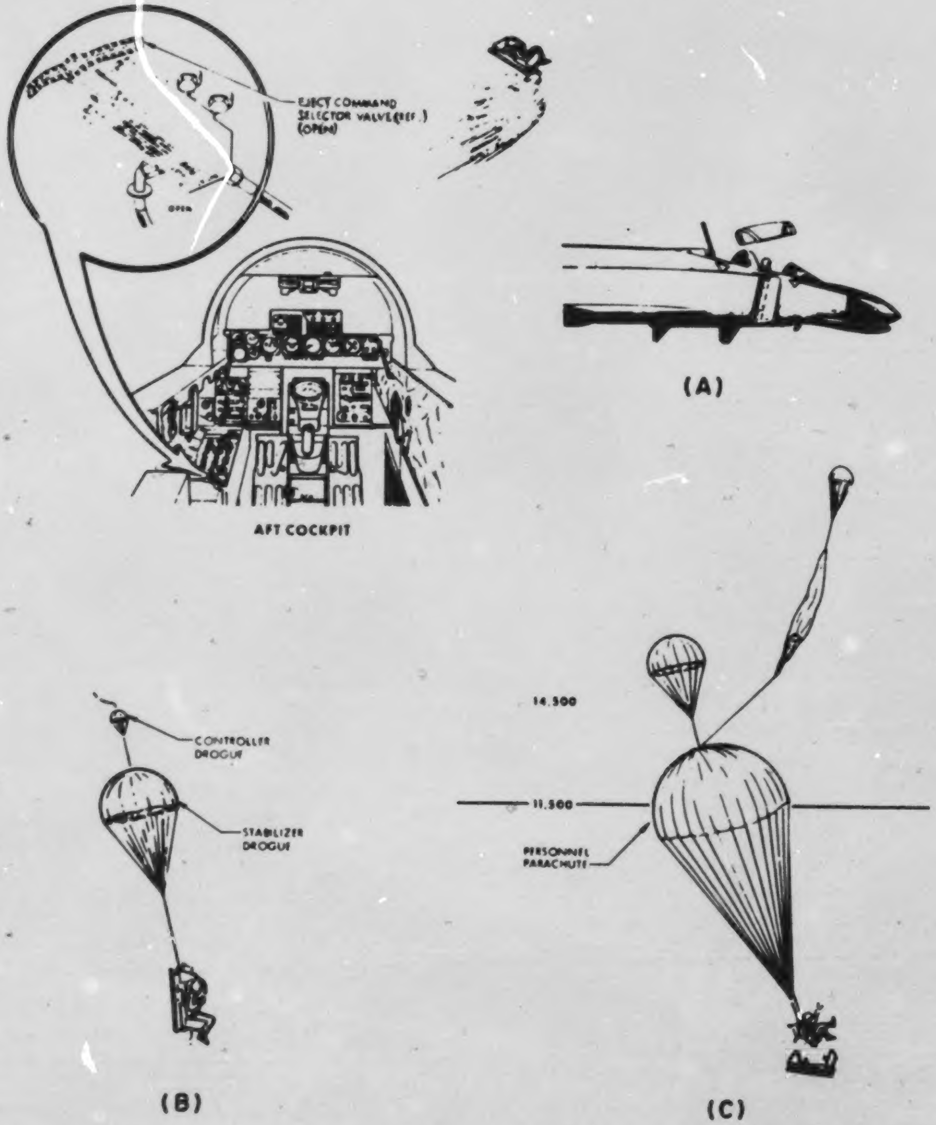
Figure 9-13.—Manual separation.

fires the igniter cartridge, causing simultaneous ignition of the propellant within the rocket motor, thus providing additional thrust to the seat ejection. (See fig. 9-14, view (A).)

Separation of the seat and inner barrel from the gun occurs when the inner and intermediate barrels are fully extended in the outer barrel. Upward seat travel after separation from the catapult gun continues by momentum of the seat mass.

Approximately three-fourths of a second after initiation, the drogue gun fires and deploys the drogue parachutes. (See fig. 9-14, view (B).) The drogue parachutes are attached to the top of the seat by the scissors mechanism and stabilize the seat. If ejection occurs at high altitude, seat descent is stabilized by the drogue parachutes until an altitude within safe limits for the seat occupant is reached. At this altitude the time release mechanism initiates a time delay sequence.

Approximately 2.25 seconds after initiation, the time release mechanism actuates, releasing the drogue parachutes, leg restraints, shoulder harness, lap belt, and personnel parachute restraints from the seat. The withdrawal line of


EJECT COMMAND
SELECTOR VALVE (REF.)
(OPEN)
OPEN
AFT COCKPIT
(A)
CONTROLLER
DROGUE
STABILIZER
DROGUE
(B)
14,500
11,500
PERSONNEL
PARACHUTE
(C)

AM.149

Figure 9-14.—High altitude dual ejection sequence.

the personnel parachute, which is linked to the drogue parachutes, is pulled when the drogue parachutes are released from the seat.

The pull exerted by the drogue parachutes on the withdrawal line deploys the personnel parachutes. Opening shock of the personnel parachute separates the occupant from the seat and a normal parachute descent follows. (See fig. 9-14, view (C).) Zero speed/zero altitude or low level ejection is basically the same as high altitude ejection except for operation of the time release mechanism.

Components

MAIN BEAM ASSEMBLY.—The main beam assembly is the main structure of the ejection seat. This assembly, which is built to withstand high g loads, supports all of the components of the seat. It is composed of two vertical beams bridged by three crossmembers. Each vertical beam has three slippers located on the inner side. These slippers engage tracks on the catapult gun and are used to mount the seat on the gun.

During ejection, the slippers slide in the catapult gun tracks and guide the seat up out of the cockpit. Two seat bucket guide tracks on the lower outboard side of each main beam provide a mounting for the seat bucket. An inclined track located on the lower outboard side of the left vertical beam provides a mounting for the rocket motor thrust angle adjustment mechanism arm.

CANOPY INTERLOCK MECHANISM.—The canopy interlock mechanism is mounted across the top of the main beam assembly. This mechanism is used to provide proper sequencing between the canopy and ejection seat during ejection and also transmits the force of the face curtain handle or secondary ejection handle to the seat mounted initiator and catapult gun firing mechanism.

A combined canopy interlock block and catapult gun firing mechanism (interdictor) safety pin assembly is installed in the interlock mechanism. (See fig. 9-15.) The safety pin safeties the catapult gun firing mechanism during aircraft ground maintenance and remains installed during flight to protect the mechanism from inadvertent operation. The interlock block segment is connected to the canopy by a cable and is pulled from the seat interlock mechanism by the canopy during the ejection sequence. The connecting linkage pulls the safety pin from the catapult gun firing mechanism. This block and various lever arrangements within the interlock mechanism prevent firing of the seat before the canopy has been jettisoned from the aircraft.

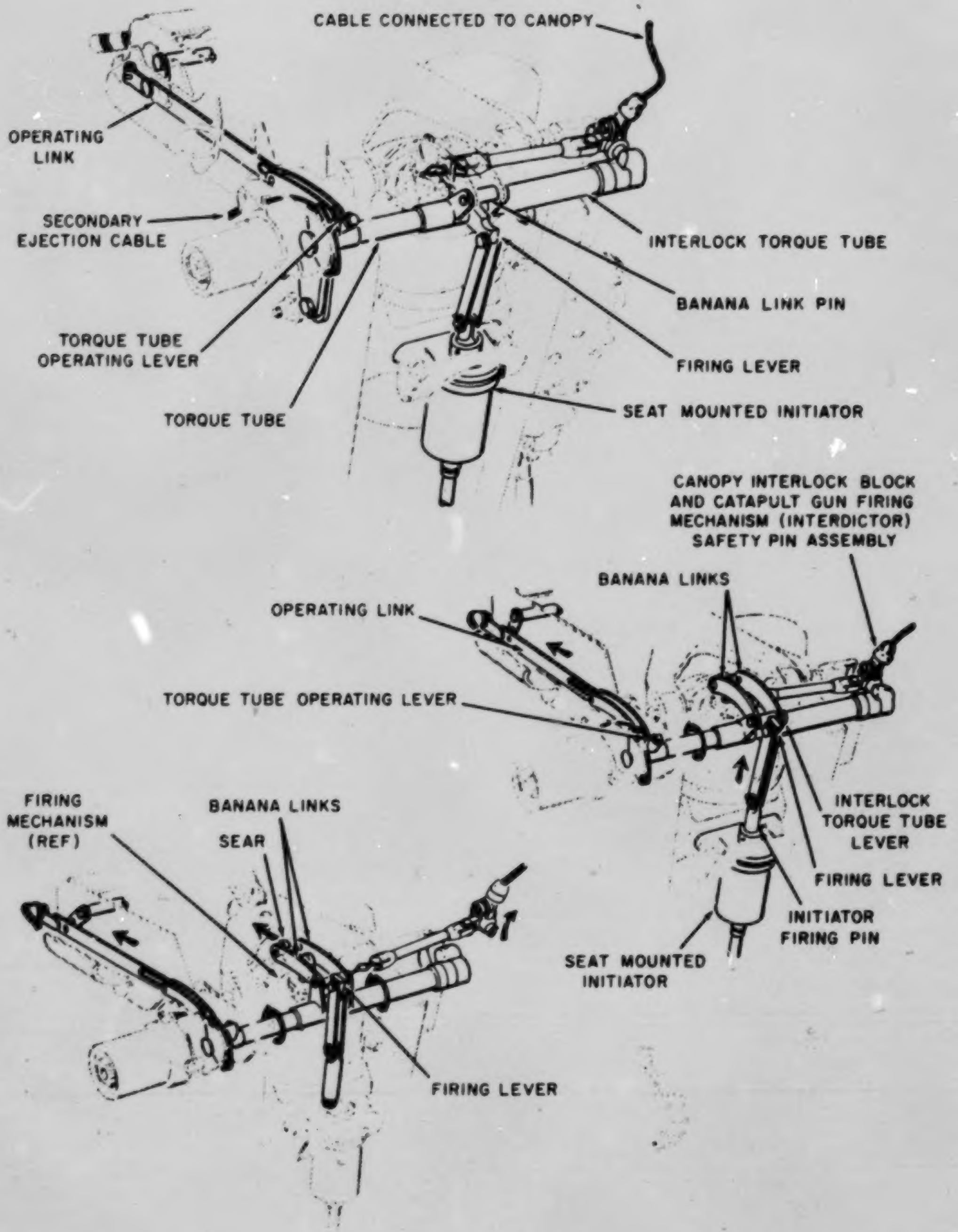
TOP LATCH MECHANISM.—The top latch mechanism is located on the top left side of the main beam assembly. The purpose of this mechanism is to lock the ejection seat to the aircraft. Locking action of the mechanism is accomplished by a plunger that protrudes through a hole in the catapult gun outer barrel. The top latch mechanism is released during the ejection sequence by the upward travel of the inner barrel of the catapult gun.

Unlocking, during maintenance, is accomplished by installing a handwheel on the top latch plunger and turning fully clockwise. When the handwheel is removed, a locking indication is given by the position of the plunger and indicator within the mechanism housing. Proper locking is indicated when the locking indicator, plunger, and mechanism housing are flush with each other. (See fig. 9-16.)

CATAPULT GUN.—The catapult gun is a pyrotechnically operated device that provides the force required to eject the seat from the aircraft. It is located between the main beams of the ejection seat and is attached to the bulkhead of the cockpit by two mounting lugs which are a part of the outer barrel. The gun is attached to the seat by the top latch mechanism, and the seat is guided up the ejection gun rails by the seat slippers mounted on the inside of the main beams.

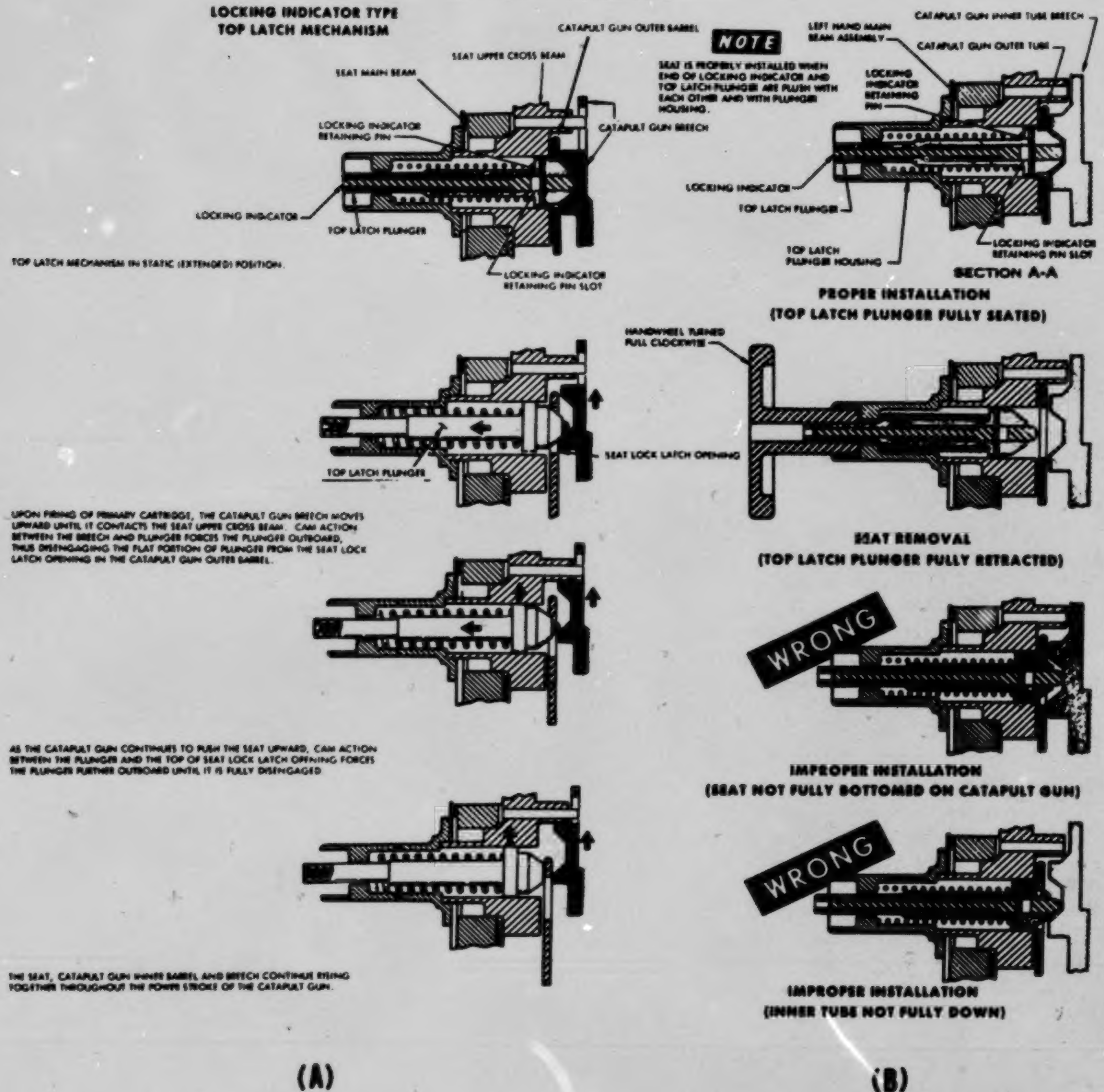
The gun is composed of four major assemblies—the firing mechanism, the inner and intermediate tubes, and the outer barrel. The gun is equipped with three explosive cartridges; a primary cartridge and two secondary cartridges. All three cartridge chambers are completely sealed against water entry, thus enabling underwater ejection should it become necessary.

The intermediate tube is open at both ends and provides an extension stroke of the gun. At its lower end is a piston with two sets of piston rings (six in each set) which bear against the inside of the outer barrel, making a gastight seal. Each set of piston rings has a spring type ring expander beneath them to insure that they are in full contact with the inner surface of the outer barrel. During ejection, the intermediate tube alignment is maintained by the top guide bushing located in the top of the outer barrel. An inner tube guide bushing is fitted inside the top of the intermediate tube and is riveted to it. The guide prevents removal of the inner tube from the


CABLE CONNECTED TO CANOPY
OPERATING LINK
SECONDARY EJECTION CABLE
INTERLOCK TORQUE TUBE
BANANA LINK PIN
TORQUE TUBE OPERATING LEVER
FIRING LEVER
TORQUE TUBE
SEAT MOUNTED INITIATOR
CANOPY INTERLOCK BLOCK AND CATAPULT GUN FIRING MECHANISM (INTERDICTOR) SAFETY PIN ASSEMBLY
BANANA LINKS
OPERATING LINK
TORQUE TUBE OPERATING LEVER
FIRING MECHANISM (REF)
BANANA LINKS
SEAR
INTERLOCK TORQUE TUBE LEVER
FIRING LEVER
INITIATOR FIRING PIN
SEAT MOUNTED INITIATOR
FIRING LEVER

AM.1181

Figure 9-15.—Canopy interlock mechanism.


LOCKING INDICATOR TYPE
TOP LATCH MECHANISM
CATAPULT GUN OUTER BARREL
SEAT UPPER CROSS BEAM
SEAT MAIN BEAM
LOCKING INDICATOR RETAINING PIN
CATAPULT GUN BREECH
LOCKING INDICATOR
TOP LATCH PLUNGER
LOCKING INDICATOR RETAINING PIN SLOT
TOP LATCH MECHANISM IN STATIC (EXTENDED) POSITION.
NOTE
SEAT IS PROPERLY INSTALLED WHEN END OF LOCKING INDICATOR AND TOP LATCH PLUNGER ARE FLUSH WITH EACH OTHER AND WITH PLUNGER HOUSING.
CATAPULT GUN INNER TUBE BREECH
LEFT HAND MAIN BEAM ASSEMBLY
CATAPULT GUN OUTER TUBE
LOCKING INDICATOR RETAINING PIN
LOCKING INDICATOR
TOP LATCH PLUNGER
TOP LATCH PLUNGER HOUSING
LOCKING INDICATOR RETAINING PIN SLOT
SECTION A-A
PROPER INSTALLATION
(TOP LATCH PLUNGER FULLY SEATED)
TOP LATCH PLUNGER
SEAT LOCK LATCH OPENING
HANDWHEEL TURNED FULL CLOCKWISE
UPON FIRING OF PRIMARY CARTRIDGE, THE CATAPULT GUN BREECH MOVES UPWARD UNTIL IT CONTACTS THE SEAT UPPER CROSS BEAM. CAM ACTION BETWEEN THE BREECH AND PLUNGER FORCES THE PLUNGER OUTBOARD, THUS DISENGAGING THE FLAT PORTION OF PLUNGER FROM THE SEAT LOCK LATCH OPENING IN THE CATAPULT GUN OUTER BARREL.
SEAT REMOVAL
(TOP LATCH PLUNGER FULLY RETRACTED)
WRONG
AS THE CATAPULT GUN CONTINUES TO PUSH THE SEAT UPWARD, CAM ACTION BETWEEN THE PLUNGER AND THE TOP OF SEAT LOCK LATCH OPENING FORCES THE PLUNGER FURTHER OUTBOARD UNTIL IT IS FULLY DISENGAGED.
IMPROPER INSTALLATION
(SEAT NOT FULLY BOTTOMED ON CATAPULT GUN)
WRONG
THE SEAT, CATAPULT GUN INNER BARREL AND BREECH CONTINUE RISING TOGETHER THROUGHOUT THE POWER STROKE OF THE CATAPULT GUN.
IMPROPER INSTALLATION
(INNER TUBE NOT FULLY DOWN)
(A)
(B)

AM.660

Figure 9-16.—Top latch mechanism sequence.

intermediate tube during maintenance. The rivet in the guide is sheared during the ejection, and the guide bushing is carried away with the inner tube and the seat. The intermediate tube remains with the aircraft after ejection, having been extended its full stroke and then snubbed to a stop by the action of 12 shock absorbing gas filled snubber rings. The snubber rings are compressed between the top guide bushing and the intermediate tube piston as the intermediate tube completes its stroke as shown in figure 9-17. The 12 snubber rings are located on the outer top of the intermediate tube as shown in figure 9-17, sequence view A.

The inner tube is open at the bottom and closed at the top by the firing mechanism and the primary cartridge. The alignment of the inner tube during its stroke is maintained by the inner guide bushing and the inner tube piston and piston ring assembly, consisting of six piston rings and one ring expander. The six rings bear against the inner wall of the intermediate tube and form a gastight seal. The inner tube contains an O-ring directly beneath the firing mechanism head fitting to prevent the entrance of water to the catapult gun and making it capable of underwater operation. The inner tube is the only portion of the ejection gun that remains with the seat during ejection.

The firing mechanism screws directly into the top of the ejection gun inner tube (primary cartridge breech) with its base seated flush against the primary cartridge. The mechanism contains a spring-loaded firing pin with its upper portion slotted to receive a wedge shaped (ramp like) sear. As the sear is pulled (or pushed) from its slot in the firing pin, its broad cam shank raises the firing pin against spring compression. As the peak of the sear cam is pulled from the firing pin, the spring drives the firing pin hard against the percussion primer in the primary cartridge to fire the cartridge and initiate the ejection sequence as previously covered.

A horseshoe type retainer ring is slipped around the firing mechanism body on installation and is lockwired to both the firing mechanism and the inner tube. This ring retains the inner tube to the ejection seat, preventing collision between the seat occupant and the inner tube during ejection. Several relief holes are located through the lower body of the firing mechanism to prevent hydraulic locking of the firing pin in the event of underwater firing. A dust cover is provided around the upper threaded base of the firing mechanism to prevent entry of foreign matter and dust into the firing body through the relief holes.

A hole in the sear is used to receive a safety pin which, when installed, prevents the sear from being withdrawn from the firing pin slot.

ROCKET MOTOR.—The rocket motor is a thrust-producing pressure vessel which provides a propulsion system for the rocket thrust phase of the ejection sequence. The rocket motor is located on the bottom of the seat bucket and consists of a number of small diameter combustion tubes, containing solid propellant, screwed into a manifold containing nozzles.(See fig. 9-10(A).) One of the combustion tubes is fitted with a mechanical firing mechanism and igniter cartridge.

As the ejection seat nears the end of the catapult gun stroke, a lanyard attached to the cockpit floor withdraws the sear from the firing mechanism allowing the spring-loaded firing pin to descend and fire the igniter cartridge, causing simultaneous ignition of the propellant.

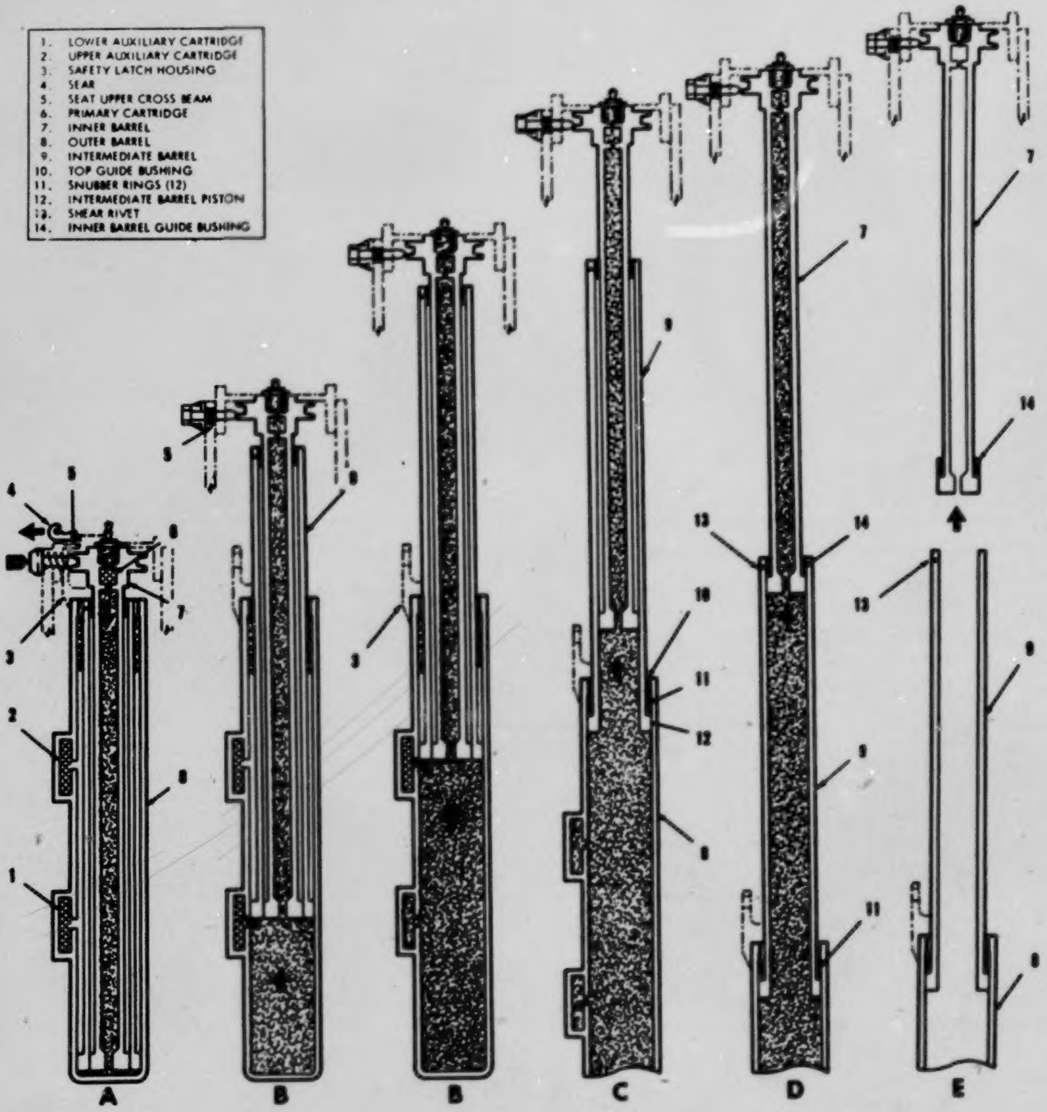
The static line dispenser is bolted under the firing mechanism and is protected by a fiberglass boot. The static line is coiled in a helical groove and held in position by four strips which shear as the line is withdrawn. The line is retained at the center of the dispenser plate by a clip which leaves sufficient line for attachment to the cockpit floor anchorage.

Two leg guards are mounted on the combustion tubes to protect the occupant's legs from the hot tubes after rocket burn-out.

A thrust angle adjustment mechanism arm is located on the aft, left side of the rocket motor. This arm engages in an inclined track on the left vertical seat beam and provides a pivoting action to the rocket motor, which adjusts nozzle angle to compensate for any change in the seat-occupant center of gravity due to raising or lowering of the seat bucket.

The service life of the rocket motor (MK 51) is 72 months from the date of propellant manufacture. The nozzle protective cover is removed and disposed of upon receipt of the rocket motor. Its use in service is not required. NavAir publication, NavAir 11-85-1 describes rocket catapults and motors used with ejection seats and provides information on the handling, stowage, and use.

DROGUE GUN.—The drogue gun is mounted on the top, left side of the main beam assembly and is used to deploy the drogue parachutes


1. LOWER AUXILIARY CARTRIDGE
2. UPPER AUXILIARY CARTRIDGE
3. SAFETY LATCH HOUSING
4. SEAR
5. SEAT UPPER CROSS BEAM
6. PRIMARY CARTRIDGE
7. INNER BARREL
8. OUTER BARREL
9. INTERMEDIATE BARREL
10. TOP GUIDE BUSHING
11. SNUBBER RINGS (12)
12. INTERMEDIATE BARREL PISTON
13. SHEAR RIVET
14. INNER BARREL GUIDE BUSHING
4
5
6
7
3
2
8
1
5
8
3
9
13
14
10
11
12
8
7
9
11
7
14
13
9
8
A
B
B
C
D
E

A SEAR (4) IS REMOVED FROM FIRING MECHANISM, FIRING PRIMARY CARTRIDGE (6). THE INNER BARREL (7) DRIVES UPWARD TO RELEASE THE TOP LATCH MECHANISM AND SEAR AGAINST THE SEAT UPPER CROSS BEAM (5).

B INNER (7) AND INTERMEDIATE BARRELS (9) RISE TOGETHER, EXPOSING THE LOWER (1) AND UPPER (2) AUXILIARY CARTRIDGES. THEY IGNITE WHEN EXPOSED AND ASSIST IN PROPELLING BOTH BARRELS AND SEAT UPWARD.

C INTERMEDIATE BARREL (9) IS SNUBBED TO A STOP BY TWELVE GAS FILLED RINGS (11) BEING COMPRESSED BETWEEN INTERMEDIATE BARREL PISTON (12) AND TOP GUIDE BUSHING (10).

D THE INNER BARREL (7) CONTINUES RISING UPWARD UNTIL IT CONTACTS THE INNER BARREL GUIDE BUSHING (14) AND SHEARS THE RIVET (13) RETAINING THE INNER GUIDE BUSHING (14) TO THE TOP OF THE INTERMEDIATE BARREL (9).

E THE INNER BARREL (7) LEAVES THE EJECTION GUN, PROPELLING SEAT FROM THE AIRCRAFT.

AM.152

Figure 9-17.—Catapult gun firing sequence.

during the ejection sequence. The gun is pyrotechnically operated and is composed of a firing body, barrel, and piston. During ejection, a trip rod pulls a sear from the firing body, actuating the drogue gun timing mechanism.

After the proper time delay has occurred, the spring-loaded firing pin is released, firing the drogue gun cartridge. Gas pressure generated by the cartridge propels the piston out of the barrel. The piston, which is attached to the drogue withdrawal line, pulls the drogue parachutes from the drogue container.

TIME RELEASE MECHANISM.—The time release mechanism (fig. 9-10 (A)) is mounted on the right beam of the main beam assembly. It is used to release the occupant from the seat and deploy the personnel parachute at a predetermined altitude during high altitude ejection and to release the occupant from the seat and deploy the personnel parachute during low level ejection approximately 2.25 seconds after initiation.

During ejection, a trip rod pulls the sear from the mechanism as the seat travels upward. With the sear removed, the mechanism assumes a ready position. Actuation of the mechanism is then controlled by the barostat and time delay. A spring-loaded plunger provides the mechanical power required to actuate the parachute and harness release mechanisms.

SCISSORS MECHANISM.—The scissors mechanism is located on top of the seat upper crossbeam. The scissors incorporate a movable jaw which is normally locked in the closed position and is released by actuation of the time release mechanism. A shackle on the drogue shroud lines is used to connect the drogue parachutes to the scissors mechanism.

DROGUE CONTAINER.—The drogue container is mounted on the upper portion of the main beam assembly. The container is used to provide stowage space for the two drogue parachutes and the face curtain. Channels on each side of the container are used to protect and provide a routing for the face curtain restraint straps. The firing linkage for the face curtain handle is located under these channels. Mounted on the left side of the drogue container is the guillotine knife blade assembly through which the personnel parachute withdrawal line is routed.

DROGUE PARACHUTE ASSEMBLY.—The drogue parachute assembly is used to decelerate and stabilize the seat during ejection and to deploy the personnel parachute after actuation of the time release mechanism.

The assembly consists of a controller drogue and a stabilizer drogue and is stowed in the drogue container. Four canvas flaps are used to secure the drogue parachutes in the container. Upon firing of the drogue gun after ejection, the drogue gun piston (attached to the controller drogue by the drogue withdrawal line) pulls the controller drogue from the container. The controller drogue in turn deploys the stabilizer drogue. The shroud lines of the stabilizer drogue are secured to the seat by the drogue shackle and scissors mechanism.

GUILLOTINE ASSEMBLY.—The guillotine assembly is a pyrotechnically operated device that is manually actuated and is used to sever the personnel parachute withdrawal line during manual separation from the seat and during crash rescue. The assembly consists of a cartridge breech, firing mechanism, gas line, and knife blade assembly.

The firing mechanism contains a simple spring loaded firing pin operated by a sear. The sear is attached to the emergency harness release handle and is pulled from the firing mechanism when the handle is rotated. The personnel parachute withdrawal line passes through a spring-loaded gate on the knife blade assembly.

Under normal ejection conditions, the withdrawal line is pulled from the knife blade assembly when the drogue parachutes deploy the personnel parachute. During manual separation from the seat, gas pressure generated by the guillotine cartridge forces the knife blade assembly upward, severing the withdrawal line and thereby releasing the personnel parachute from the drogue parachutes. (See fig. 9-18.)

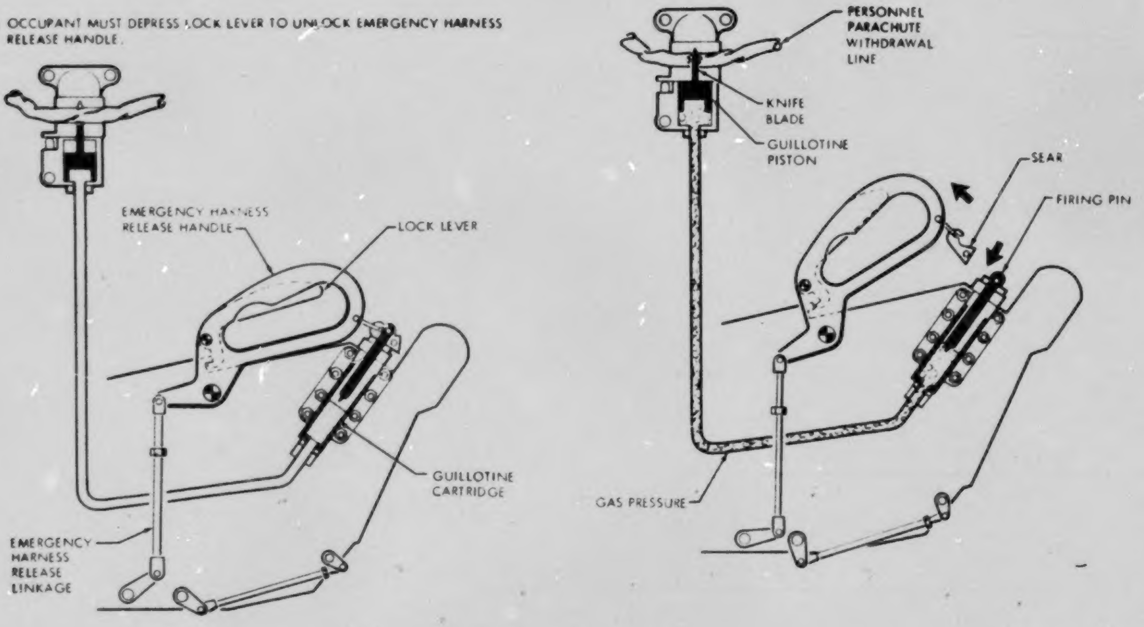
The occupant may then push free from the seat and pull the D-ring which deploys the personnel parachute for normal descent to the ground.

In addition to firing the guillotine, the emergency harness release handle releases the lap belt, harness loop straps, leg restraint cords, and personnel parachute restraint straps through the emergency harness release linkage.

GAS POWERED INERTIA REEL.—The gas powered inertia reel is located between the seat main vertical beams and approximately level with the crewmember's shoulders. The inertia reel has two functions to perform in conjunction with the ejection seat.

The reel automatically locks the crewmember in the ejection seat when the crewmember

A OCCUPANT MUST DEPRESS LOCK LEVER TO UNLOCK EMERGENCY HARNESS RELEASE HANDLE.


EMERGENCY HARNESS RELEASE HANDLE
LOCK LEVER
GUILLOTINE CARTRIDGE
EMERGENCY HARNESS RELEASE LINKAGE
PERSONNEL PARACHUTE WITHDRAWAL LINE
KNIFE BLADE
GUILLOTINE PISTON
SEAR
FIRING PIN
GAS PRESSURE

B PULLING EMERGENCY HARNESS RELEASE HANDLE AFT, EXTRACTS SEAR FROM FIRING PIN IN THE FIRING MECHANISM.

C FIRING PIN STRIKES PERCUSSION CAP ON THE CARTRIDGE. GAS PRESSURE GENERATED BY CARTRIDGE TRAVELS TO GUILLOTINE PISTON THRU CONNECTING TUBING.

D THE GAS PRESSURE FORCES THE GUILLOTINE PISTON, TO WHICH A KNIFE BLADE IS ATTACHED, UP TO SEVER THE PERSONNEL PARACHUTE WITHDRAWAL LINE.

E OCCUPANT IS NOW ABLE TO PUSH FREE OF THE SEAT AND PULL THE "D" RING WHICH DEPLOYS THE PERSONNEL PARACHUTE FOR A NORMAL DESCENT TO THE GROUND.

NOTE

IN ADDITION TO FIRING THE GUILLOTINE, THE EMERGENCY HARNESS RELEASE HANDLE RELEASES THE LAP BELTS, HARNESS LOOP STRAPS, LEG RESTRAINT CORDS AND PERSONAL PARACHUTE RESTRAINT STRAPS.

AM.153

Figure 9-18.—Guillotine operation.

is subjected to excessive forward longitudinal or transverse accelerations, or combination thereof, and automatically positions and restrains the crewmember in the ejection seat during emergency escape.

The reel consists of two harness loop straps wound on a spring-loaded drum, an inertia mechanism that senses strap velocity, and a power retraction device. The inertia reel locks when the shoulder harness manual control handle is placed in the lock (forward) position, when excessive g forces are sensed, and when the gas powered retraction device is actuated.

One type of reel can be manually unlocked after inertia locking occurs by cycling the shoulder harness manual control handle full forward, then full aft. The other type reel can be unlocked after inertia locking occurs by relieving tension on the harness loop straps. The gas powered retraction device can only be used during emergency escape.

The crewmember is positioned in the seat during ejection by the harness loop straps retracting. A ballistic gas line and initiator are mounted on the reel. When the seat is installed in the aircraft, the male half of the ballistic gas line quick disconnect is mated with the female half, located on the right-hand structural seat rail.

SEAT BUCKET POSITIONING ACTUATOR.—The seat bucket positioning actuator is located on the rear of the seat and is attached to the seat bucket and main beam assembly. It is used to adjust the bucket height according to the needs of the occupant and is controlled by the seat height adjustment switch.

The actuator consists of an electric motor, reduction gears, screwjack, and two limit switches and has a total stroke of 6.0 inches. The actuator is connected to the seat bucket with a quick release pin that is used to release the bucket from the actuator during seat bucket removal.

SEAT BUCKET.—The seat bucket makes up the lower part of the seat assembly and provides a mounting for the survival kit and rocket motor. Linkage for the various actuating and release mechanisms are also incorporated in the seat bucket. The bucket is supported by the seat framework through four adjustable runners mounted in the rear of the bucket. The runners are a slide fit in guide tracks bolted to the outer face of each main vertical beam.

Several design features are incorporated which permit the bucket to be removed from the seat when required to provide access to various components in the cockpit without removing the entire seat assembly.

LEG RESTRAINT MECHANISM.—Two identical leg restraint mechanisms are located on the forward side of the seat bucket. (See fig. 9-10 (B).) The mechanism function is to draw in and secure the occupant's legs to the seat during ejection. Each leg restraint mechanism consists of a restraint cord, snubber unit, and finger ring.

During flight, sufficient slack is left in each cord to allow the occupant free leg movement. This slack may be adjusted by the occupant pulling out on the appropriate finger ring on the front of the seat bucket. This allows more cord to be pulled out to provide sufficient slack. Excessive slack may be taken up by reaching under the bucket and pulling the excess cord through the snubber.

The leg restraint manual release handle located on the left side of the seat bucket is provided to release both restraint cord lockpins from their receptacle. This allows the occupant to leave the seat without removing the calf garters. The attach fittings on the restraint cords incorporate a shear rivet.

During ejection, the slack in each cord is taken up by the upward movement of the seat. This pulls the occupant's legs against the seat and clear of obstructions. When all the slack has been removed in the cords, the tension of the cord will cause the rivet in each roller to shear, separating the cords from the aircraft.

The occupant's legs are held secure during ejection by the snubber units, which retain the cords. Upon operation of the time release mechanism, the leg restraint lockpins are released, freeing the occupant's legs prior to separation from the seat.

PERSONNEL PARACHUTE.—The personnel parachute consists of a large diameter main canopy and a small pilot chute and shoulder harness riser assembly. The parachute is packed into a horseshoe shaped, hardshell container mounted on a central support bolted to the seat.

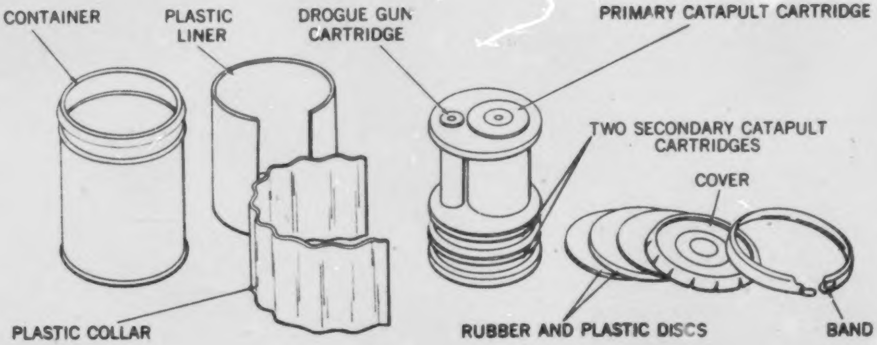
The container is secured by two restraining straps which run from the seat harness lock mechanism to attaching points on each side of the drogue parachute container, and by two cords on the bottom of the container which connect to the survival kit sticker clip straps.

A parachute pack opening spring is mounted on each side of the seat between the parachute container and support. During ejection, when the restraining straps are released, the springs push the top of the parachute container forward for positive deployment.

The shoulder harness riser assembly performs a dual purpose. During flight, it secures the occupant in the seat by means of two attachment rollers at shoulder level through which the seat harness loop straps are threaded. During ejection, it retains the occupant in the seat until parachute deployment and then is utilized as the parachute harness by means of two attachment fittings connected to the occupant's integrated harness.

Cartridges

The catapult gun primary and auxiliary cartridges and the drogue gun cartridge are handled as sets. The set of four cartridges is packaged in a tin can. (See fig. 9-19.) The outside of the can is not color coded for the Martin-Baker cartridge sets manufactured after December 1967. Earlier sets were color coded brown. The inside is lined with a strip of sheet



AM.154

Figure 9-19.—Cartridge set.

plastic. The two flat secondary catapult cartridges are placed on a sponge rubber pad at the bottom of the can, one above the other, separated by a plastic disc. Primary and drogue gun cartridges are inserted in holes in a plastic disc suspended vertically above the secondary catapult cartridges, surrounded by a corrugated plastic collar.

A rubber disc under the lid seals the can when the notched rim of the cover is clamped over a rounded lip at the top edge of the can. A channeled tin band surrounds the lid and the top edge of the can.

A white label with black ink printing, located on the outside of the container, provides data which identifies the federal stock number, contents, type escape system, the quantity and drawing number of the cartridges, the LOT number, and the MBA (assembly) date (month-year). The guillotine and rocket motor igniter cartridges are ordered separately when needed.

WARNING: Because of their explosive nature, extreme care must be taken when handling the ejection seat cartridges. The catapult gun primary, drogue gun, and guillotine cartridges must be removed before seat removal and installed only after the seat has been reinstalled in the aircraft. Also, the guillotine cartridge must be removed before seat bucket removal and installed only after the bucket has been reinstalled in the aircraft, and the rocket motor igniter lanyard must be disconnected from the cockpit floor before seat bucket removal.

IDENTIFICATION.—The primary, drogue, and guillotine cartridges are percussion type and have a primer on the cap end of the cartridge. They have identifying marks on the cap end of the cartridge case. The secondary cartridges are disc shaped and are flame ignited. Their identifying marks are printed in black type on the face of the cartridge. The code number for the rocket motor igniter cartridge is MBEU2250RU.

HANDLING.—It is of the utmost importance that explosive components of seats be handled in accordance with approved safety practices and common sense.

If a cartridge is removed from a cartridge-actuated device for inspection or safety reasons, it should be marked for identification in accordance with NavAir publication, NavAir 11-100-1, so that it can be reinstalled in the same device from which it was removed. Cartridges are designed to perform specific functions and several quite different cartridges may all be about the same size. An underpowered cartridge inadvertently installed will probably not do the job for which the device was designed and an overpowered cartridge may blow up and destroy the device—either of which may cause an ejectee to sustain serious or fatal injuries.

A cartridge which has no identification marks, or which has obscure or indefinite identification marks, should not be installed in any cartridge-actuated device. Cartridges should be handled as little as practicable to minimize risk of fire, explosion, and damage from accidental causes. A deformed or dented cartridge might not fit properly in the equipment for which it was designed; therefore, in handling cartridges and cartridge-actuated devices, special care should be taken to prevent them from being struck or dropped.

The publication, NavAir 11-100-1, Cartridges and Cartridge-Actuated Devices For Aircraft and Associated Equipment, contains all essential handling precautions for all types of cartridges and cartridge-actuated equipment. This publication is the final authority on all matters relating to descriptions, nomenclature, handling instructions, and service life limitations on the subject material.

AGE LIMITATIONS.—Explosives are subject to age deterioration. This deterioration is hastened in an overly warm environment. Cartridges in containers should be stored in a cool dry place where they can be readily inspected.

The cartridges in the Marin-Baker seat are subject to a maximum life of 5 years from the date of manufacture. The only way a cartridge can remain usable for the full 5 years is to leave it in the hermetically sealed container for 2 1/2 years or more before installation in an aircraft.

Whenever a Martin-Baker cartridge is installed in an aircraft, it is subject to two limitations on its useful life: (1) It cannot remain installed past the date which is 5 years past its date of manufacture; and (2) it cannot remain installed beyond 2 1/2 years after opening the factory-sealed container in which it was shipped. For this reason it is important that the hermetically sealed container not be opened until the cartridge set is needed. Furthermore, when the container is first opened, every cartridge contained in it (whether to be installed then or not) should immediately be indelibly marked with the date of the expiration of its useful life (determined by the 5 years from the date of manufacture OR 2 1/2 years from the date of opening of the container, whichever is earlier).

There are several terms currently used which are intended to refer to the lives of these cartridges. "Service life" refers to the time interval between the date of manufacture and the time the cartridge or set must be removed from the storage shelf or the aircraft and disposed of. This naturally varies from 2 1/2 to 5 years. "Shelf life" refers to the time a cartridge set can remain unopened on the shelf in storage ready for use. The maximum is 5 years. "Installed life" refers to the period of time that begins to pass on the date the container is opened. The maximum is 2 1/2 years.

Maintenance

Ejection seats and associated components are carefully designed, manufactured, and tested to insure dependable operation within established limits. Such equipment must function perfectly the first time it requires use. Malfunction or failure to operate when needed, usually results in severe injury or death to the pilot and crewmembers. Utmost care must be observed in maintaining escape system equipment in perfect condition.

Proper handling and strict conformance to the step-by-step maintenance procedures presented in the Maintenance Instructions Manual and the applicable Maintenance Requirements Cards are mandatory and cannot be overemphasized. Many of the steps will seem repetitious, however, they are necessary to insure correct tolerances, rigging, installation, etc.

NOTE: The information presented in this manual must not be used in place of the information provided in the applicable Maintenance Instructions Manual. The information provided in this section includes only general coverage on the types of maintenance checks and depth of maintenance allowed at the Organizational level of maintenance. Reproducing the complete step-by-step procedures provided in the MIM would be impractical and soon outdated.

Organizational maintenance of the rocket assist ejection system of the F-4 is limited to checking operation of the seat bucket positioning actuator, arming and dearming, and removal and installation of the seat, seat bucket, catapult gun, personnel parachute, and the lumbar pad.

Checkout procedures are provided for use during the accomplishment of periodic inspections or for performing trouble analysis. The items to be checked and the frequency for conducting these checks are established by the Periodic Maintenance Requirements Manual (being replaced by Periodic Maintenance Information Cards).

Maintenance of each type of ejection seat requires special tools and techniques. Reference to the appropriate MIM or Maintenance Requirement Card deck will, in most cases, provide all the information needed to properly maintain the seat system and components.

EJECTION SEAT SAFETY PRECAUTIONS.—The Martin-Baker ejection seat has several inherently dangerous features which are a definite hazard to uninformed and/or careless personnel and that should be covered prior to performing any maintenance. Whenever the aircraft is on the ground, all safety pins must be installed as shown in figure 9-20 and not removed until the aircraft is ready for flight. Caution must be observed at all times during maintenance of and around the seat(s) to avoid injury and equipment damage by explosive devices of the seat. Safety precautions and correct procedures cannot be overemphasized.

Personnel must at all times observe all safety regulations. Keep all cartridges away from live circuits and under no circumstances should any person reach within or enter an enclosure for the purpose of servicing or adjusting equipment without the immediate presence or assistance of another person capable of rendering aid.

When removing cartridges for inspection or safety reasons, they must be marked for identification so they can be reinstalled in the same device from which removed; and under no circumstances should an unmarked or unidentified cartridge be installed in any cartridge-actuated device.

Cartridges should be handled as little as practicable to minimize risk of fire, explosion, and damage from accidental causes, and all safety devices must be kept in good order and used only as designated.

Cartridges must be stored where they will not be exposed to direct rays of the sun, and be protected from extremely high temperatures; and when in containers, they must be stored in a cool, dry place where they can be readily inspected.

The seat must always be disarmed before removal from the aircraft or firing of the seat may occur. While handling percussion fired cartridges, extreme caution must be exercised not to drop cartridges as they can fire upon impact.

The rocket motor and firing mechanism located under the seat bucket presents a hazard similar to the catapult and drogue gun cartridges. Extreme caution must be exercised when performing any function in the vicinity of the rocket motor such as: pulling the ground safety pin or adjusting the leg restraint cords. Lowering the seat on a foreign object or yanking on a tangled leg restrain cord could withdraw the firing mechanism sear and cause inadvertent firing of the rocket.

No portion of the body should be over the top of the drogue gun when performing maintenance as accidental firing would almost certainly cause injury.

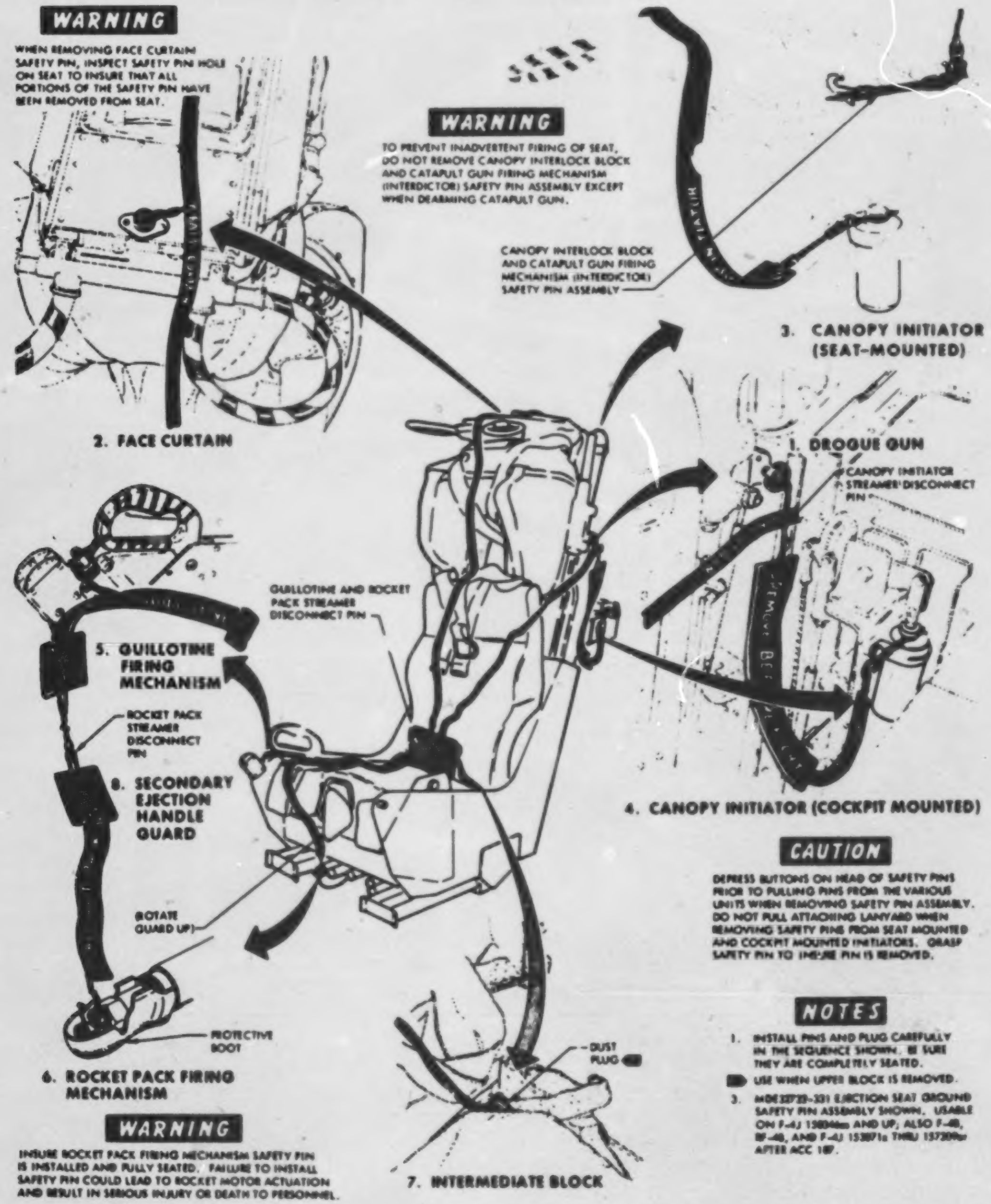
Foreign objects brought into the cockpit by crewmembers or maintenance personnel, such as flashlights, tools, etc., represent a real safety hazard. Foreign objects can lodge in critical mechanisms such as the firing mechanism of the rocket and cause actuation or malfunction. Utilizing the inventory list for their toolbox, maintenance personnel must conduct a personal inventory for all items brought into the cockpit during maintenance before leaving the job.

SEAT BUCKET POSITIONING CHECK.—This check is performed to verify that the seat bucket moves freely with no binding or drag and automatically stops when the full up or down limit is reached, that the bucket stops and locks in any desired position when the seat switch is released, that the guillotine gas lines flex outboard with adequate clearance, that electrical leads to the seat actuator do not stretch when the seat moves throughout its full range of travel, and that there is adequate clearance between the rocket motor and the cockpit structure.

The check is performed while sitting in the seat to apply necessary weight on the seat bucket. The actuator motor has a duty cycle limit of not more than 30 seconds operating time allowed within a 10-minute period. Operating the actuator excessively could damage it due to overheating.

SEAT DEARMING AND ARMING.—Seat dearming for purposes of removal and installation of the ejection seat or to accommodate the performing of maintenance consists of removing the catapult gun firing mechanism for removal of the primary cartridge, removal of the drogue gun cartridge, disconnecting of the emergency release handle link from the guillotine firing mechanism (safety pin installed), disabling of the rocket motor firing mechanism, disconnecting of the seat-mounted initiator firing links, and disconnecting and capping of the canopy initiator lines from seat and bulkhead mounted initiators.

Preparation for dearming includes opening the canopy, installing the safety struts, and insuring that all pins of the ground safety pin assembly are properly installed, and that the secondary firing handle guard is in the UP position as illustrated in figure 9-20.


2. FACE CURTAIN
3. CANOPY INITIATOR (SEAT-MOUNTED)
CANOPY INTERLOCK BLOCK AND CATAPULT GUN FIRING MECHANISM (INTERDICTOR) SAFETY PIN ASSEMBLY
1. DROGUE GUN
CANOPY INITIATOR STREAMER DISCONNECT PIN
GUILLOTINE AND ROCKET PACK STREAMER DISCONNECT PIN
5. GUILLOTINE FIRING MECHANISM
ROCKET PACK STREAMER DISCONNECT PIN
8. SECONDARY EJECTION HANDLE GUARD
ROTATE GUARD UP
PROTECTIVE BOOT
6. ROCKET PACK FIRING MECHANISM
4. CANOPY INITIATOR (COCKPIT MOUNTED)
DUST PLUG
7. INTERMEDIATE BLOCK

WARNING

WHEN REMOVING FACE CURTAIN SAFETY PIN, INSPECT SAFETY PIN HOLE ON SEAT TO INSURE THAT ALL PORTIONS OF THE SAFETY PIN HAVE BEEN REMOVED FROM SEAT.

WARNING

TO PREVENT INADVERTENT FIRING OF SEAT, DO NOT REMOVE CANOPY INTERLOCK BLOCK AND CATAPULT GUN FIRING MECHANISM (INTERDICTOR) SAFETY PIN ASSEMBLY EXCEPT WHEN DEARMING CATAPULT GUN.

CAUTION

DEPRESS BUTTONS ON HEAD OF SAFETY PINS PRIOR TO PULLING PINS FROM THE VARIOUS UNITS WHEN REMOVING SAFETY PIN ASSEMBLY. DO NOT PULL ATTACHING LANYARD WHEN REMOVING SAFETY PINS FROM SEAT MOUNTED AND COCKPIT MOUNTED INITIATORS. GRASP SAFETY PIN TO INSURE PIN IS REMOVED.

NOTES

1. INSTALL PINS AND PLUG CAREFULLY IN THE SEQUENCE SHOWN. BE SURE THEY ARE COMPLETELY SEATED.
2. USE WHEN UPPER BLOCK IS REMOVED.
3. MDE32720-331 EJECTION SEAT GROUND SAFETY PIN ASSEMBLY SHOWN. USABLE ON F-4J 1583[illegible] AND UP; ALSO F-4B, RF-4B, AND F-4J 153071[illegible] THRU 1572[illegible] AFTER ACC 187.

WARNING

INSURE ROCKET PACK FIRING MECHANISM SAFETY PIN IS INSTALLED AND FULLY SEATED. FAILURE TO INSTALL SAFETY PIN COULD LEAD TO ROCKET MOTOR ACTUATION AND RESULT IN SERIOUS INJURY OR DEATH TO PERSONNEL.

AM.1182

Figure 9-20.—Ground safety pin assembly.

CATAPULT GUN DEARMING.—Figure 9-21 illustrates the firing mechanism and primary cartridge removal steps. With the catapult gun firing mechanism (interdiction) safety pin installed in the sear mechanism, push forward on the sear and disconnect the banana links (fig. 9-21, view A). The canopy interlock block will pop out of the interlock mechanism when the links are disconnected and care must be exercised not to inadvertently allow the interdictor safety pin to be pulled.

Next, carefully remove the interdictor safety pin and wind several turns of lockwire on the sear through the safety pin hole as shown in

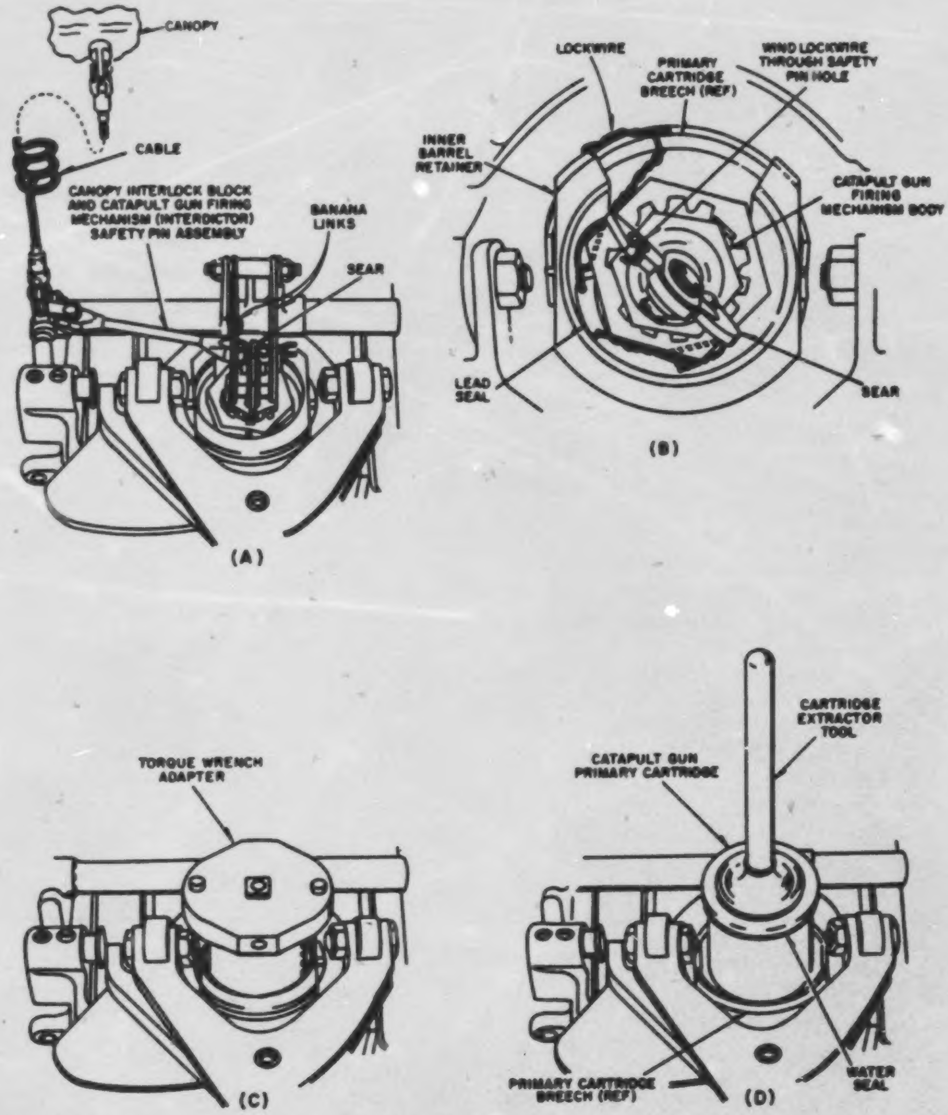

CANOPY
CABLE
CANOPY INTERLOCK BLOCK AND CATAPULT GUN FIRING MECHANISM (INTERDICTOR) SAFETY PIN ASSEMBLY
BANANA LINKS
SEAR
(A)
LOCKWIRE
PRIMARY CARTRIDGE BREECH (REF)
WIND LOCKWIRE THROUGH SAFETY PIN HOLE
INNER BARREL RETAINER
CATAPULT GUN FIRING MECHANISM BODY
LEAD SEAL
SEAR
(B)
TORQUE WRENCH ADAPTER
(C)
CARTRIDGE EXTRACTOR TOOL
CATAPULT GUN PRIMARY CARTRIDGE
PRIMARY CARTRIDGE BREECH (REF)
WATER SEAL
(D)
AM.1183

Figure 9-21.—Catapult gun dearming.

figure 9-21, view B. This will prevent withdrawal of the sear during the removal of the firing mechanism.

Cut and remove the lockwire from the firing mechanism body, the inner barrel retainer, and the primary cartridge breech. When removing the lockwire and the lead seals on ejection seat devices, do not break the wire by bending back and forth as this can cause material damage such as enlarged or cracked lockwire holes.

Use the torque wrench adapter and a flexible hinged breaker handle to remove the firing mechanism by turning counterclockwise. (See fig. 9-21, view C).

The cartridge is removed from its breech using the extractor tool as shown in figure 9-21, view D.

NOTE: The extractor tool is essentially a suction cup with a handle. Raise the cartridge up from its seat only far enough to secure a handhold on it. This will eliminate the possibility of the cartridge falling off the tool if it is completely withdrawn with the tool. The primary cartridge is a percussion type and can fire on impact if dropped or accidentally hit against a sharp object. Handle the cartridge carefully and immediately place it in a cartridge block. Record the seat position (forward or aft cockpit) and the aircraft bureau number on the cartridge block data card then place the block in a suitable container for storage.

Place the firing mechanism fingertight in the breech of the inner barrel to prevent contamination of the gun and rotate the banana links forward. Closing the canopy with the banana links rotated aft will damage the links and the canopy.

Drogue Gun Dearming.—Figure 9-22 illustrates the removal of the drogue gun cartridge. The withdrawal line is removed from the drogue gun barrel and the bolt reinserted in the withdrawal shackle. Cut and remove the lockwire and lead seal from the firing body and barrel, and loosen and remove the barrel from the body, being careful that the cartridge does not accidentally drop out of the barrel. Remove the cartridge, using the removal tool shown in figure 9-22 and place it in the cartridge block. If the cartridge cannot be removed with the extractor tool, replace the barrel and the cartridge. DO NOT attempt to dislodge the cartridge by hammering on the pistom or using a punch rod. Record the appropriate data in the same manner as was required for the catapult primary cartridge and place in the container for storage. Reinstall the barrel fingertight into the firing body.

Disabling the Rocket Motor Firing Mechanism.—Disabling of the rocket motor firing mechanism consists of the following steps:

1. Remove the right leg guard forward of the firing mechanism to gain easier access to the mechanism and the firing lanyard.
2. Using a sear withdrawal tool, carefully install the special safety pin, then disconnect the firing lanyard from the firing mechanism sear and the cockpit floor attach fitting. (See fig. 9-10 (A).) When dearming is completed a dearming tag is affixed to the face curtain handle.

Arming the Catapult Gun.—Arming of the catapult gun is essentially a reversal of the dearming procedure. When the seat has been removed for calendar inspection, all seat functional checks must be completed and signed off on the appropriate maintenance data collection forms prior to arming.

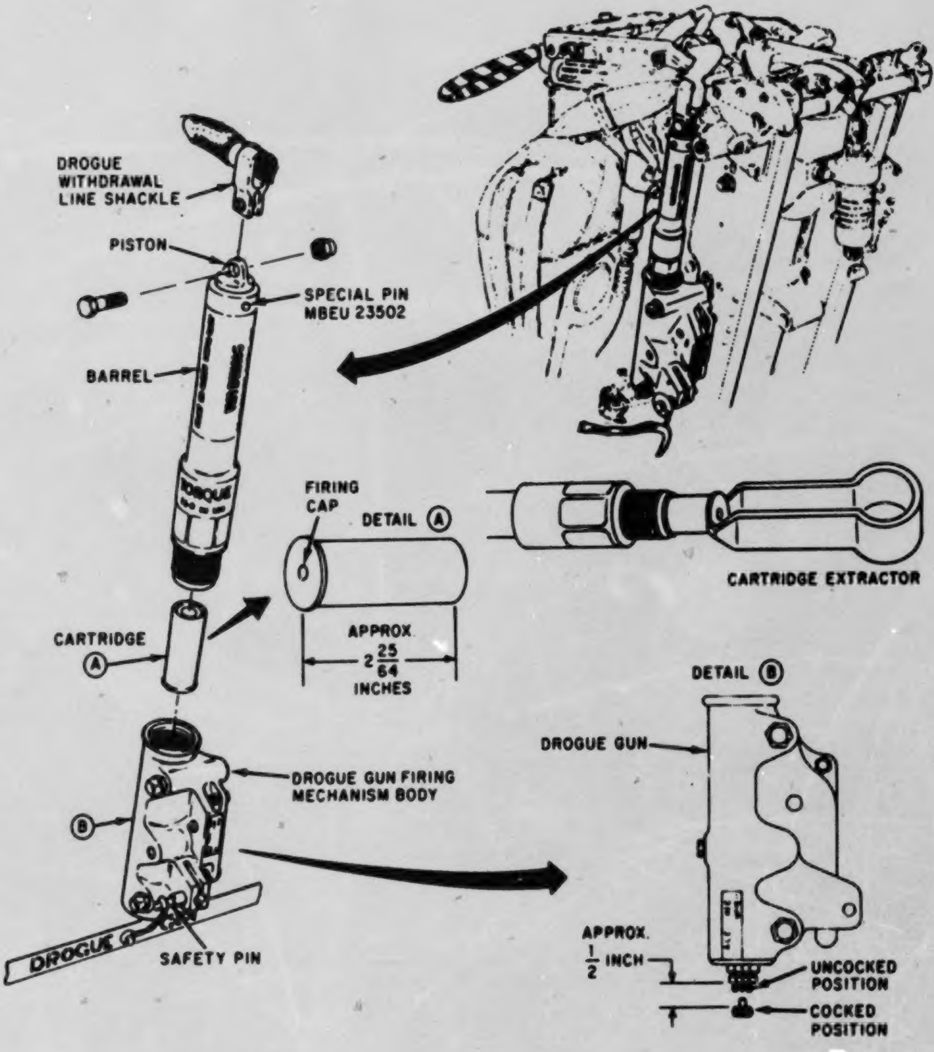
The cavity of the catapult gun is checked for cleanliness prior to inserting the primary cartridge. Any water, oil, or other debris that may be present in the gun must be removed as such materials can seriously reduce the catapult gun forces, which are critical during the ejection sequence.

Check the information on the cartridge block data card to insure that the original cartridge location is maintained and insert the cartridge.

The firing mechanism sear is safetied as shown in figure 9-21, view B, and the firing pin must not protrude from the bottom of the firing mechanism.

Prussian blue marking dye is applied to the bottom of the firing mechanism and the mechanism is installed in the gun breech and tightened to the torque specified in the Maintenance Instructions Manual and the Maintenance Requirements Cards. Index marks are penciled on the large hex nut and inner tube and then the firing mechanism is removed (counting the number of full turns required) to check for transfer of the blue dye to the top of the primary cartridge. Transfer of the blue dye to the cartridge top indicates proper seating of the firing mechanism against the cartridge. If dye transfer does not occur the cause must be determined and corrected.

The dye is then removed from the cartridge and the firing mechanism and the cartridge and firing mechanism reinstalled and torqued. The number of turns and previous alignment marks should correspond to those established on the previous torquing.


DROGUE WITHDRAWAL LINE SHACKLE
PISTON
SPECIAL PIN MBEU 23502
BARREL
FIRING CAP
DETAIL Ⓐ
CARTRIDGE EXTRACTOR
APPROX 2 25/64 INCHES
CARTRIDGE Ⓐ
DETAIL Ⓑ
DROGUE GUN
DROGUE GUN FIRING MECHANISM BODY
Ⓑ
DROGUE
SAFETY PIN
APPROX. 1/2 INCH
UNCOCKED POSITION
COCKED POSITION

AM.1184

Figure 9-22.—Drogue gun cartridge removal.

A Quality Assurance Representative will lockwire and affix a lead seal on the lockwire of the installed firing mechanism as shown in figure 9-21, view B, prior to the banana links and canopy interlock mechanism being replaced.

The lockwire insures that the components remain secure against vibration, and the lead seal is to indicate that the device to which it is affixed has been inspected and is in a ready-for-flight condition. The lead seal further identifies which activity and what personnel inspected and approved a devices condition for operational use.

Arming the Drogue Gun.—Remove the barrel from the gun and insure that the special pin (fig. 9-22) is properly installed in the barrel and piston. Insure that the drogue gun is cocked and the sear and ground safety pin are installed in the firing body. The cocking indicator for the drogue gun is illustrated in figure 9-22, detail B. Insert the correct cartridge into the drogue gun barrel. Insure that the firing pin is not protruding above the bottom surface of the cartridge chamber, then carefully screw the barrel into the firing body and tighten to the specified torque.

NOTE: If a new drogue gun firing body or barrel is being installed, pretorquing of the gun barrel into the body with a dummy cartridge installed in lieu of a regular cartridge must be accomplished as specified in the applicable Maintenance Instructions Manual.

The Quality Assurance Representative will lockwire the barrel to the firing body and affix a lead seal prior to reconnecting of the withdrawal line shackle to the drogue gun piston.

Arming of the seat is complete following reconnecting of the guillotine release handle to the sear, reconnecting of the rocket motor firing lanyard, reconnecting of the canopy initiator lines to the seat and bulkhead mounted initiators, and reconnecting of the seat mounted initiator firing link.

The complete dearming and arming sequence must be accomplished in accordance with the applicable Maintenance Requirements Cards or the Maintenance Instructions Manual procedures EVERY time.

GUILLOTINE CARTRIDGE REMOVAL AND INSTALLATION.—Although removal of the guillotine cartridge is not a part of the dearming procedure for the Martin-Baker H-7 seat its removal is a step of the seat removal procedure covered in the Maintenance Instructions Manual. Figure 9-23 illustrates the steps of the cartridge removal and installation.

Removal of the guillotine cartridge is initiated by cutting and removing the lockwire and lead seal between the firing mechanism and the guillotine body. The sear was disconnected from the emergency harness release handle as a step of the dearming sequence. Remove the sear safety pin and insert several turns of lockwire through the safety pin hole as shown in figure 9-23, view E.

Unscrew the firing mechanism and remove it and the cartridge from the housing. If the cartridge does not come out with the firing mechanism, push the extractor tool illustrated in view B over the cartridge and withdraw it from the housing. If the cartridge is jammed in the housing, it can generally be broken free by moving the extractor back and forth. Should jamming of the cartridge occur, it must be replaced and the old cartridge disposed of in accordance with ordnance procedures for disposal of unserviceable ammunition. The AME turns the unserviceable cartridge over to the Armament work center for disposal.

If the cartridge is to be reinstalled (depending on service life expiration date and condition), it is stored in the same manner as was described for the catapult and drogue gun cartridges.

The firing mechanism is reinstalled in the housing fingertight to prevent contamination of the assembly and connecting lines.

Reinstalling the Guillotine Cartridge.—Prior to installing a cartridge in the guillotine firing mechanism, insure that the sear is lockwired and that the firing pin does not protrude from the base.

Temporarily insert the cartridge into the firing mechanism and check the cartridge flange for out-of-round distortion by using a micrometer as shown in figure 9-23, view F. Rotate the cartridge a complete turn. The flange should not bind on the micrometer at any point. If it does, replace it.

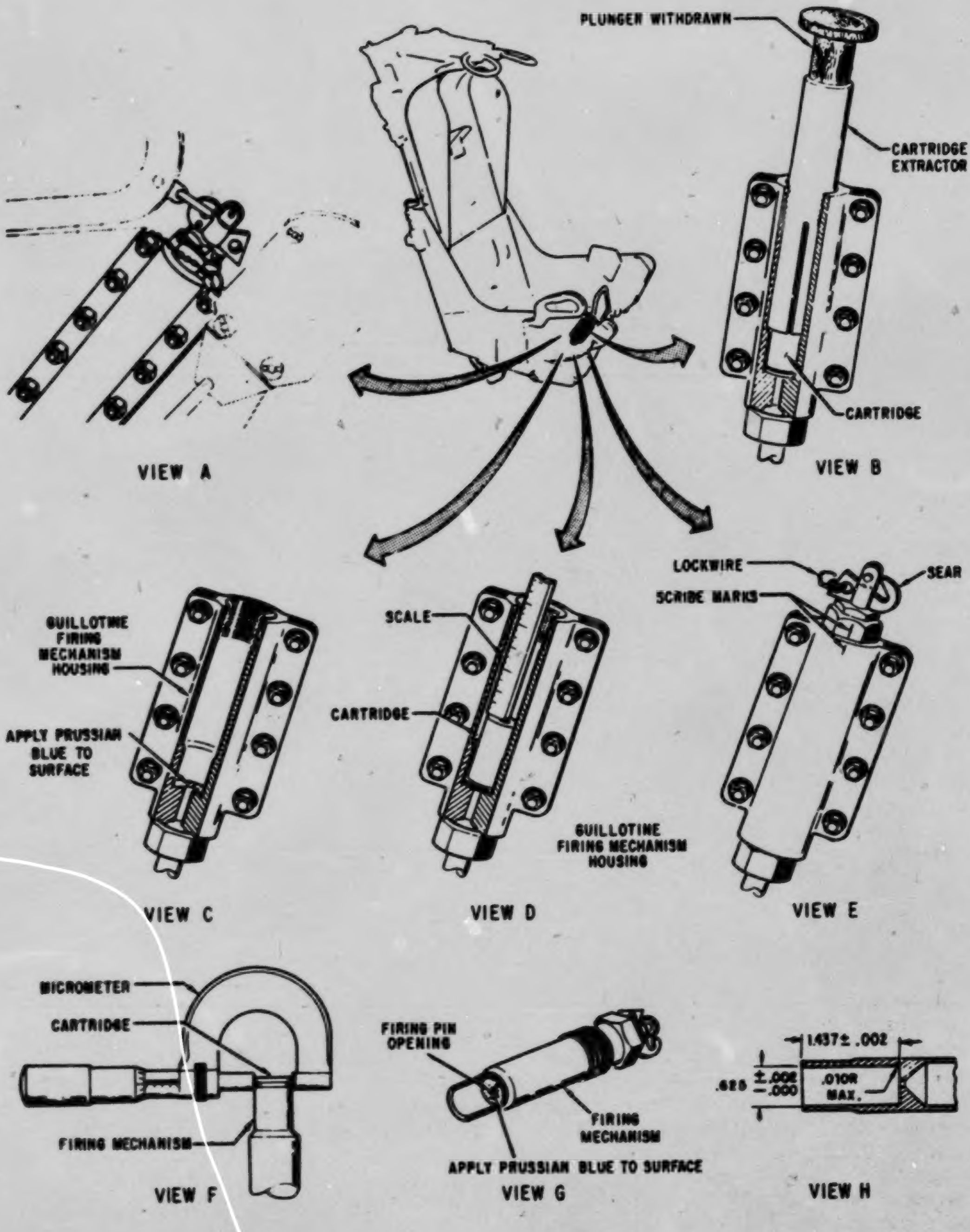
Prussian blue marking dye is used as illustrated in figure 9-23, views C and G, to insure that the cartridge makes proper contact with both the firing mechanism and the bottom of the housing.

The measurement between the top of the cartridge and the top of the housing is obtained as shown in figure 9-23, view D. The cartridge is inserted into the housing using the extractor tool shown in view B. The extractor plunger is pushed to release the cartridge from the extractor.

Once it is established that the cartridge will properly seat in the housing, the prussian blue dye is removed from the cartridge and the housing, and the cartridge is reinstalled in the housing. The measurement between the top of the cartridge and the housing is rechecked and should be the same as the previous measurement.

Next, prussian blue dye is again applied to the base of the firing mechanism and the mechanism is installed in the housing (cartridge is installed in the housing) and tightened to the torque specified in the Maintenance Instructions Manual.

Scribe marks are placed on the hex nut of the firing mechanism and the housing (fig. 9-23, view E) and the firing mechanism is removed. The number of full turns required for removal is counted and recorded to be referred to in a later step.


PLUNGER WITHDRAWN
CARTRIDGE EXTRACTOR
CARTRIDGE
VIEW A
VIEW B
LOCKWIRE
SEAR
SCRIBE MARKS
GUILLOTINE FIRING MECHANISM HOUSING
APPLY PRUSSIAN BLUE TO SURFACE
SCALE
CARTRIDGE
GUILLOTINE FIRING MECHANISM HOUSING
VIEW C
VIEW D
VIEW E
MICROMETER
CARTRIDGE
FIRING MECHANISM
FIRING PIN OPENING
FIRING MECHANISM
APPLY PRUSSIAN BLUE TO SURFACE
1.437± .002
.625 ± .002 − .000
.010R MAX.
VIEW F
VIEW G
VIEW H

AM.1185

Figure 9-23.—Guillotine cartridge removal and installation.

The top of the cartridge is again checked for transfer of the prussian blue dye. If transfer has occurred the dye is removed and the cartridge and firing mechanism reinstalled in the housing. Count the number of turns required for tightening to the specified torque. The number of turns required should correspond to those previously recorded and the scribe marks should be aligned to indicate proper assembly.

The Quality Assurance Representative will lockwire and affix a lead seal to the device as shown in figure 9-23, view A. The lockwire is then removed from the safety pin hole of the sear and the standard safety pin installed.

REMOVAL AND INSTALLATION (MARTIN-BAKER).—Three men are generally required to remove and install a Martin-Baker seat using either hoist or manual methods.

WARNING: Seat removal should never be attempted until the seat has been properly dearmed.

Before beginning removal of the seat, all equipment required should be readily accessible and in good working order. The middle of the job is no time to have to stop and perform equipment maintenance. Such equipment includes: a hoisting sling; a maintenance cradle to place the removed seat in; an overhead hoist (crane or chainfall) to do the actual seat lifting (minimum capacity, 500 pounds); an alignment fixture which is used to extend the Martin-Baker rails so that the seat will remain aligned after the seat slippers clear that portion of the rails which is attached to the aircraft; and the necessary tools to disconnect miscellaneous rods, cable, and straps from the aircraft.

Disconnect the lower block of the personnel services disconnect, leg restraint cords, time release mechanism and drogue gun trip rods, gas lines, electrical connections, and all other seat-to-aircraft connections in accordance with the instructions provided in the Maintenance Instructions Manual. Retract the top latch mechanism by installing the handwheel and turning it full clockwise.

On aircraft equipped with classified equipment destruct systems which are actuated by the ejection seat leaving the aircraft, failure to tie the IFF switch down before removing the seat may result in destruction of expensive equipment. Also, on all aircraft, the Identification Friend or Foe (IFF) switch must be held in the DOWN position when the seat is removed or the emergency signal will be transmitted whenever electrical power is applied to the aircraft.

Attach the hoisting bar and the hoist to the seat and slowly raise the hoist until the recommended maximum upward tension is registered on the hoisting sling safety scale. A sharp shake or pull on the seat should then break any friction holding the seat in place. If the seat does not start to rise, review the previous steps in the prescribed procedure to insure that the seat is free to rise.

If the seat utilizes an alignment fixture, it is installed prior to lifting the seat free of the aircraft. When the seat (and alignment fixture, if used) is lifted clear of the aircraft the seat assembly must be steadied to prevent oscillations which could result in collision damage or injury to personnel if the seat struck the aircraft or persons.

When the unit is safely clear of the aircraft, transfer it to the maintenance cradle and remove the hoisting sling and attached lifting device. The removed seat should be tagged with the Bureau Number of the aircraft from which removed and its position in the aircraft (pilot, copilot, bombardier/navigator, etc.).

Prior to installing or reinstalling an ejection seat in an aircraft, various checks of seat and aircraft condition should be made. The following is a typical list which may vary between seat types and aircraft:

Check the lower disconnect block or blocks, cables, and hoses, for signs of corrosion, fraying, and wear, and for general security of all fittings and attaching parts.

Check electrical quick-disconnect plugs and cable assemblies for signs of corrosion, chafing, and for general security of all fittings and attaching parts.

Check the ejection gun attaching parts for signs of corrosion and wear, proper lockwiring, and security of all attachment points.

Check the cockpit deck area below the seat for signs of corrosion and general cleanliness.

Operate seat tilt and/or seat height adjustment mechanisms through the full range of movement to check for clearance and operation.

Before starting the actual installation procedure, check to see that the seat is disarmed and that the necessary shipping pins are installed. Check for proper alignment of all slippers and locating pins so that these seat fixtures will not have to be adjusted while the seat is hoisted. Attach the hoisting sling to the attach points on the seat and position the hoist directly over the seat. Mate the sling eye with the hoisting hook and lift the seat clear of its support.

Following specific instructions in the appropriate Maintenance Instructions Manual install the seat in the aircraft.

NOTE: Martin-Baker seats must be installed on their mated ejection guns (catapult tubes). On some other seats the catapult tubes are completely interchangeable between seats and aircraft. Be sure the aircraft manufacturer's recommendations are followed exactly with respect to interchangeability.

When the seat is in place, it must be secured to the catapult gun inner tube and, in the case of Martin-Baker seats, also secured to the outer tube by the top latch mechanism. See figure 9-16 for proper locking. The LS-1 and the ESCAPAC rocket catapults employ an internal locking device so that when the seat is made fast to the inner tube it is also fixed with respect to the outer tube.

After making certain that the seat is bottomed and properly secured in the aircraft, all disconnect blocks, triprods, cables, and straps must be reconnected. As the seat is armed each safety device should be installed immediately. Reactivate the IFF switch.

Lap belt and shoulder harness maintenance is another important area of the AME rating. Anchoring of safety belts and harnesses vary with different type aircraft. Regardless of the aircraft type there are a few simple principles that can be applied to the installation of all safety harnesses. Some texts refer to the entire arrangement (safety belt and shoulder harness) as being the safety harness, while others mean only the shoulder harness.

Whenever following installation directions, it is imperative that they be followed exactly. The belt and shoulder harness have been designed to withstand stresses which are beyond human tolerance. However, if the strength of the anchoring points do not measure up to the tensile strengths of the belts and harness the dependability of the entire assembly can be lost.

General installation rules are as follows:

1. On ejection seats, insure that retaining pins or sticker clips, as applicable, are properly connected to the harness and/or seat. On other than ejection seats, use only steel nuts and bolts. Use only stop nuts, or the castellated type, which require a cotter pin through the bolt and castellation of the nut to prevent loosening.

NOTE: Apply nuts, especially those requiring cotter pins, in such a way that they will not catch on the parachute or clothing.

2. Wherever possible belts and harness should be installed in a manner that avoids all chafing against the seat or adjacent aircraft structure. Certain designs make this impossible, and when such is the case, make certain the webbings being carried in a new direction are placed over the top of a strong structural member, whether it be on the seat or some other part. The structural member acting as a guide must be smooth.

3. The installation must not interfere with other equipment and the escape procedures outlined for a specific aircraft. In no way must the path of an ejection seat be obstructed.

4. Not all seats in aircraft face forward. Therefore, in order to establish the correct relationship, left sides of belts and shoulder harness are installed on the left side of the seat as viewed from its rear.

5. All belts incorporating manual release latches are installed with the latches on the left side so that they can be released with the right hand.

6. The hardware used in the assemblies must be so designed as to prevent the webbing from abrading and fraying. Any filing of rough edges must be accompanied by a plating process to prevent rust.

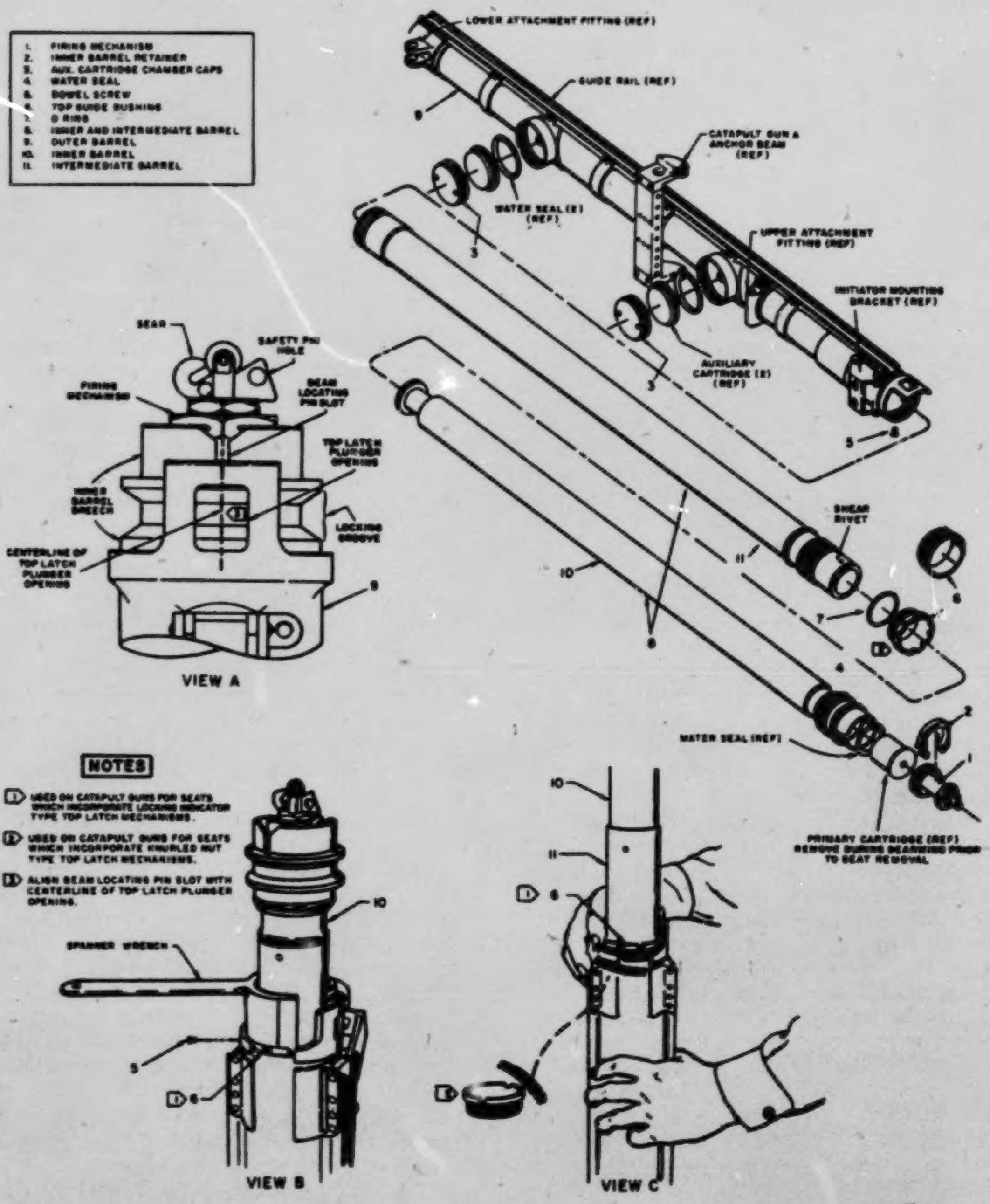
FUNCTIONAL SEAT CHECKS.—Ejection seats removed from the aircraft as a part of the calendar inspection requirements must undergo a variety of functional checks as specified in the Maintenance Requirements Card deck.

In depth testing of the catapult gun firing mechanism, the time release mechanism, the drogue gun, and a complete ejection seat mechanism operational check requires that the seat be transported to a specially equipped seat shop. Such shops are normally equipped with seat mounting fixtures which allow the seat to be maneuvered so that various sections of the seat are more easily worked on.

The functional checks required by the Maintenance Requirements Cards for the F-4 (Martin-Baker H-7) ejection seat are discussed in this section in the order in which they appear in the MRC deck.

Catapult gun Maintenance.—Figure 9-24 illustrates the disassembly of the catapult gun. The outer barrel of the gun is supported in a vise with gun clamp blocks during disassembly and assembly.

The auxiliary cartridges are removed by cutting the lockwire and removing the cartridge chamber caps using a torque wrench adapter


1. FIRING MECHANISM
2. INNER BARREL RETAINER
3. AUX. CARTRIDGE CHAMBER CAPS
4. WATER SEAL
5. DOWEL SCREW
6. TOP GUIDE BUSHING
7. O RING
8. INNER AND INTERMEDIATE BARREL
9. OUTER BARREL
10. INNER BARREL
11. INTERMEDIATE BARREL
LOWER ATTACHMENT FITTING (REF)
GUIDE RAIL (REF)
CATAPULT GUN & ANCHOR BEAM (REF)
WATER SEAL (2) (REF)
UPPER ATTACHMENT FITTING (REF)
INITIATOR MOUNTING BRACKET (REF)
AUXILIARY CARTRIDGE (2) (REF)
SHEAR RIVET
WATER SEAL (REF)
PRIMARY CARTRIDGE (REF) REMOVE DURING DEARMING PRIOR TO SEAT REMOVAL
SEAR
SAFETY PIN HOLE
FIRING MECHANISM
BEAM LOCATING PIN SLOT
TOP LATCH PLUNGER OPENING
INNER BARREL BREECH
LOCKING GROOVE
CENTERLINE OF TOP LATCH PLUNGER OPENING
VIEW A
NOTES
1 USED ON CATAPULT GUNS FOR SEATS WHICH INCORPORATE LOCKING INDICATOR TYPE TOP LATCH MECHANISMS.
2 USED ON CATAPULT GUNS FOR SEATS WHICH INCORPORATE KNURLED NUT TYPE TOP LATCH MECHANISMS.
3 ALIGN BEAM LOCATING PIN SLOT WITH CENTERLINE OF TOP LATCH PLUNGER OPENING.
SPANNER WRENCH
VIEW B
VIEW C
1
2
3
4
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11

AM.1186

Figure 9-24.—Catapult gun.

and a hinged breaker handle. Discard the water seals. Pull the cartridges with an extractor tool similar to the one used in removing the primary gun cartridge (fig. 9-21). The cartridge expiration dates are checked and recorded for verification against the logbook entry, then turned over to ordnance personnel for stowage until needed in the reassembly of the gun. The chamber caps are reinstalled fingertight to prevent contamination.

Remove the dowel screw (item 5) and the firing mechanism from the gun. Partially withdraw the inner tube from the intermediate tube approximately 6-8 inches to accommodate removal of the top guide bushing (6) using the spanner wrench as illustrated in figure 9-24, views B and C. It is now possible to remove the inner and intermediate tubes from the outer tube.

The inner and intermediate tubes are held together by an inner tube guide bushing and a shear rivet. The inner and intermediate tubes should not be separated and care must be exercised to prevent shearing of the rivet during remaining maintenance steps on the gun.

The gun parts are cleaned with P-D-680 solvent and blown dry using clean, low-pressure air. The tubes are inspected for freedom of movement within each other and for corrosion. All other parts are checked for corrosion, thread condition, deformation, cracks, wear, and general condition. Note that the 12 compression rings are located at the top (outer) portion of the intermediate tube.

Check the inner bottom of the outer barrel for accumulated oil deposits and remove any accumulation. Replace any defective parts then commence reassembly.

A thin coating of oil is applied to the telescoping tubes. New water seals are required throughout the assembly and they are lubricated lightly with grease (MIL-G-21164). The two sets of piston rings at the bottom of the intermediate tube must be installed in the ring grooves with their end gaps evenly staggered to provide effective sealing. Insure that the ring expander is installed prior to installation of the rings.

The inner and intermediate tubes are inserted into the outer barrel leaving about 6-8 inches extended to accommodate further reassembly. Manually push the top guide bushing and the intermediate tube in until it bottoms, and tighten the top guide bushing with the spanner wrench until the dowel screw hole in the guide lines up with the hole in the outer tube. Install the dowel screw and center punch the edge to lock it in place.

Push the inner tube into the intermediate tube until it bottoms, and align the beam locating pin slot with the top latch plunger opening as shown in figure 9-24, view A.

Draw the auxiliary cartridges from the weapons work center and insure that they are the correct ones for that seat and aircraft so that the original cartridge location is maintained. Remove the chamber caps and install the new water seals, then the cartridges, so that the igniter holes face inward. The chamber caps can not be installed if the cartridges are in backwards. Make sure that the plastic shipping discs have been removed from the cartridges. Install the chamber caps and tighten to the specified torque. Quality Assurance will lockwire each cap and affix a lead seal.

CATAPULT GUN FIRING MECHANISM CHECK.—Inspect the firing mechanism for corrosion, cleanliness, and condition of the threads. Place the mechanism in a vise as shown in figure 9-25. Lift the firing pin, using the firing pin extractor tool, and remove the sear. Check for binding or restriction when withdrawing the sear or moving the firing pin.

With the sear removed, firing pin spring tension is checked by attaching a spring scale (0-25 pound range) to the extractor tool and checking that the firing pin does not start to move until a load of at least 8 pounds is applied. If tension is below the required amount, replacement parts are available to restore the mechanism to an acceptable condition.

With the firing pin protruding from the base of the firing mechanism, check the pin protrusion, using a special depth micrometer or go-no-go gage as specified in the MIM. The pin should protrude a specified amount. If it is not within limits, repair as necessary to return it to an acceptable condition. Repair instructions are provided in the Maintenance Instruction Manual.

When these checks on the firing mechanism are completed, lift the firing pin and install the sear. Make sure that the firing pin does not protrude with the sear installed. Install the firing mechanism fingertight in the catapult gun breech.

TIME RELEASE MECHANISM CHECK.—The time release mechanism checkout is composed of two checks—time delay check and barostat check. Figure 9-26 illustrates the test switch assembly, the timer, and the barostat checkout vacuum

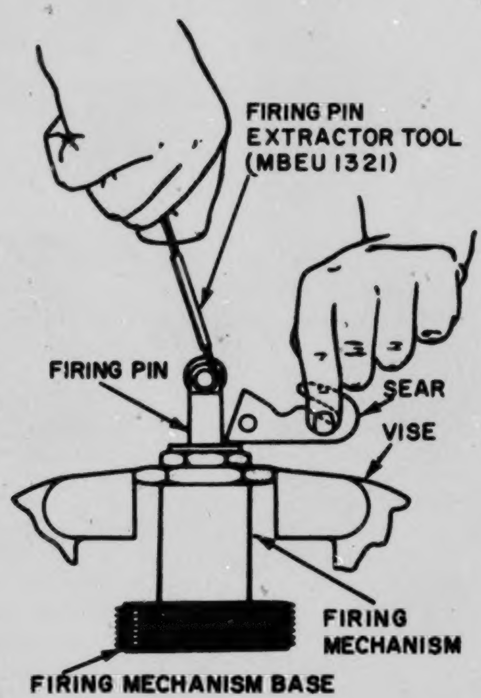

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Figure 9-25.—Firing mechanism sear removal and installation.

chamber needed to perform the two checks. Frequent reference to this figure should be made during the discussion of these checks.

For the time delay check, disconnect the bungee cord from the trip rod and remove the time release mechanism from the ejection seat. Install the switch actuator collars (2) and (3) on the shackle release and rack plungers, respectively. Mount the time release mechanism on the test assembly (4) so that the three locating pins are engaged in the three mounting holes of the mechanism and the tang on the switch actuator collar (3) is engaged in the track of the test switch assembly. Adjust stop (5) to bear against the mounting pad and tighten the three clamps (6).

Connect the trip rod assembly to the sear, using the chain attaching pin (7). Install the trip lever on the trip lever arm and pull the lever to fully seat the sear on the time release mechanism. Push the trip lever forward gently to remove slack in the trip rod assembly and remove the lever. Observe that the sear does not move from the seated position.

NOTE: The trip lever is also used on the cocking mechanism for the plungers.

Install the trip lever on the cocking mechanism and cock the rack and shackle plungers. Loosen the switch mounting bracket bolts and position each bracket so that the roller on the switch actuator is on the slope of the switch actuator collar.

Connect the test leads from a multimeter to pins C and D of the connector (10) and adjust the switch actuator bolt on the trip rod assembly until the start switch (12) is just open (multimeter needle returns to 0). Continue adjustment of the bolt an additional one-quarter turn. Place the power switch (13) in the ON position, connect the multimeter to pins A and B of the connector and adjust switch actuator bolt (14) until the light switch (15) is just open. Continue adjustment of bolt one-quarter turn and turn the power switch to the OFF position.

Next connect the multimeter to pins E and F of the connector and adjust switch actuator bolt (16) until the stop switch (17) is just open. Continue the adjustment one-quarter turn and then connect the test switch assembly to the timer (18) and connect the timer to an electrical power source. Place the timer switch ON and zero the timer pointers.

Install the trip lever on the trip lever arm and apply a rapid pushing force to the lever to disengage the sear. Check the reading of the timer when the mechanism has completed actuation. The timer must show an elapsed time of 2.25 (±0.10) seconds. Repeat the test procedure at least three times in order to insure positive test results within limits.

In performing the barostat check, repeat all of the above procedures down through adjusting the stop switch (17), and then place the complete mechanism in the barostat checkout chamber (19).

Connect the cable from the test switch assembly to the vacuum chamber, plug into the electrical power source, and place the power switch (13) in the ON position. Turn the selector valve handle (20) to the manual pump position, close the bleed valve (21), and set the pressure altimeter scale to 29.92. Using the hand pump (22) observe the altitude on the altimeter (23) and increase the chamber altitude to 20,000 feet.

NOTE: If the chamber evacuation with the hand pump is slow, lubricate the pump plunger with grease and insure that the test assembly is sealed by using the latches provided in the handles. If an auxiliary vacuum source is available, it may be used in lieu of the hand pump. Connect the vacuum source to the vacuum fitting as shown in figure 9-26, view A-A, and turn the handle of the selector valve to the MOTOR OPERATION PUMP position.

Pull the sear from the release mechanism with the trip lever; the mechanism must not operate. Slowly bleed air into the chamber by opening the bleed valve (21) and observe the altimeter. The release mechanism must start to actuate between 14,500 and 11,500 feet.

NOTE: Actuation of the release mechanism is signaled by illumination of the indicator light (25) and stoppage of chamber descent by the solenoid. Chamber altitude may be reduced to zero with the bleed valve after the power switch is placed in the OFF position.

Repeat the above test procedure at least three times to insure positive test results.

Drogue Gun Checkout.—The drogue gun checkout consists of three separate checks; a time delay check, a pin protrusion check, and a spring compression check.

Disconnect the bungee cord from the trip rod and remove the drogue gun from the ejection seat and place in a vise-mounted holding tool as shown in figure 9-27.

NOTE: The drogue gun checkout can also be made with the gun installed on the seat. Checkout discussed in this section is with the gun removed.

The drogue gun is cocked as illustrated in figure 9-28.

The steps of the cocking procedure with the drogue gun mounted in the holding tool are the same as those shown in figure 9-28. Insert the sear into the slot of the locking plunger with the cam side outboard as illustrated in view A. Lock the sear in place by pushing in on the locking plunger. The drogue gun ground safety pin may be used for this purpose as shown in view B. With the lock plunger forward as it should be, it will not protrude into the safety pin hole.

The hex head cocking indicator and washer are then removed from the bottom of the firing body and the threaded portion of the cocking tool is screwed in place (view C). Pull the cocking tool its full limit. This causes the firing pin base to ride over the slope on the end of the locking plunger and push it outwards until the slot in the firing pin body is opposite the locking plunger. The spring pressure on the ball-end plunger forces the locking plunger inward to engage the slot in the firing pin. If the operator looks through the safety pin hole he can momentarily see the end of the locking plunger appear, then snap into engagement with an audible click. (See view E.) When tension is released on the cocking tool, return motion should be approximately one-eighth inch as the mechanism locks in the cocked position.

While cocking, no binding or restriction other than normal spring tension should be felt.

Next attach the start and stop switch assemblies to the drogue gun and connect the plugs from these assemblies to their receptacles in the relay control section of the time clock as illustrated in figure 9-27, view A. Connect the time clock to an electrical power source and turn the unit on. If both hands are not zeroed, they are returned to zero using the trip lever just above the clock face.

To perform the time delay check, pull the sear sharply from the drogue gun, causing the timer to start. The timer will stop when drogue gun escapement fires. A time delay of 0.65 to 0.85 second should be registered on the time clock.

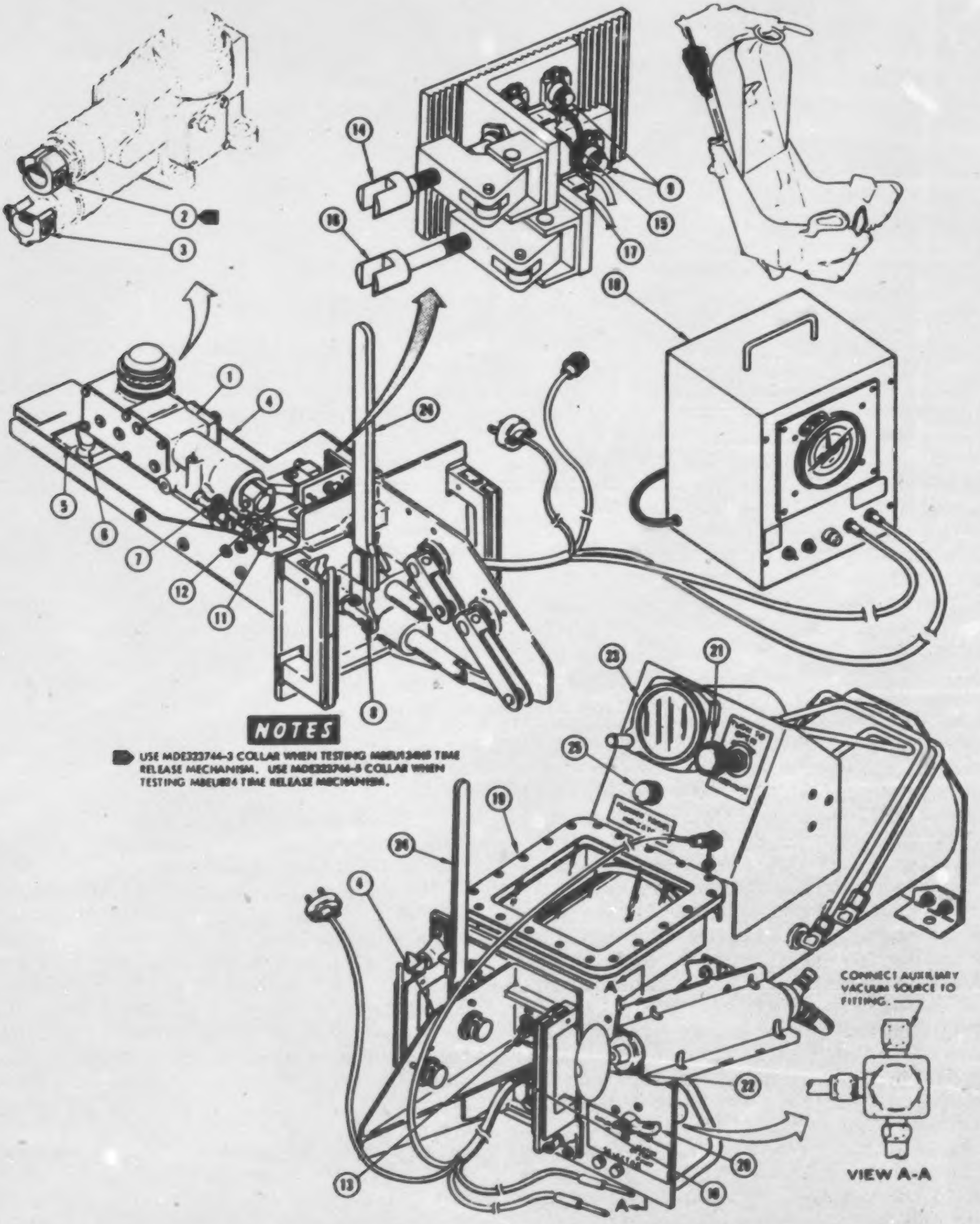
When the test is completed, remove the power equipment from the drogue gun, then remove the gun from the holding tool.

The pin protrusion check is accomplished using a depth micrometer. Measure the distance from the base of the bore to the top of the firing body as shown in figure 9-27, view B. Record the distance. Next measure the distance from the end of the protruding firing pin to the top of the firing body (view C) and subtract this from the first measurement to obtain pin protrusion. Pin protrusion should be from 0.094 to 0.140 inch.

The spring compression is checked as shown in figure 9-27, view D. The cocking tool is inserted into the gun and a spring scale connected to the handle. Spring tension on the handle is gradually increased until the firing pin just starts to move. The scale reading should be 8 to 15 pounds.

If the drogue gun does not meet all the requirements of the checkout it must be replaced with a new one. A new one must be tested prior to installation.

Cock the gun and insure that the firing pin does not protrude. When properly cocked the cocking indicator will be extended approximately 1/2 inch. (See fig. 9-22.) The drogue gun piston


14
2
3
16
9
15
17
10
1
4
24
5
6
7
12
11
8
NOTES
USE MDE323744-3 COLLAR WHEN TESTING MBEU13480 TIME RELEASE MECHANISM. USE MDE323744-5 COLLAR WHEN TESTING MBEU8824 TIME RELEASE MECHANISM.
23
21
25
18
24
4
A
22
CONNECT AUXILIARY VACUUM SOURCE TO FITTING.
VIEW A-A
20
19
13
A

AM.659

Figure 9-26.—Time release mechanism checkout.

Nomenclature for Figure 9-26.

1. Time release mechanism.
2. Switch actuator collar.
3. Switch actuator collar.
4. Test switch assembly.
5. Stop.
6. Clamp (3 each).
7. Pin.
8. Trip lever arm.
9. Bolt (4 each).
10. Connector.
11. Switch actuator bolt.
12. Switch (start).
13. Power ON/OFF switch.
14. Switch actuator bolt.
15. Switch (light).
16. Switch actuator bolt.
17. Switch (stop).
18. Timer 134GT1041-T5 (component of test unit).
19. Barostat checkout vacuum chamber.
20. Selector valve.
21. Bleed valve.
22. Hand pump (vacuum).
23. Altimeter.
24. Trip lever.
25. Plunger travel indicator lamp.

is removed from the barrel, cleaned and lightly lubricated, and reinserted into the barrel using a new O-ring and split shear pin.

SEAT MECHANISM OPERATIONAL CHECKS.—Operational seat checks required on the ejection seat during the aircraft calendar inspection include checking the emergency harness release handle operation, a face curtain and secondary ejection check, harness takeup mechanism check, leg restraint mechanism check, guillotine mechanism check, and a scissor mechanism check.

Harness Release Mechanism Check.—When checking for harness release due to firing of the timer release mechanism the following seat conditions exist. The emergency harness release handle should be in the down and locked position. Insure that the time release mechanism (installed on the seat after functional check) is cocked and that the shoulder harness loop straps, the leg restraint cords, and the lap belt are properly connected to the seat.

Next place the time release mechanism cocking tool on the time release mechanism and insert the cocking pin in the hole on the shackle release plunger as shown in figure 9-29.

With light pressure applied to the handle of the cocking tool, pull the sear from the time release mechanism. This will allow the rack plunger to extend. When the plunger has completely extended, relieve pressure on the cocking tool to allow the shackle release plunger to fully extend. The leg restraint cords, lap belt, harness loop straps, and the drogue shackle must release from the seat.

When this part of the check is completed, reconnect the leg restraint cords, loop straps, and lap belt to their respective quick-release fittings on the seat.

Prior to continuing the check the time release mechanism must be cocked. Cocking is accomplished as follows:

The sear and trip rod assembly are positioned so that the small end of the clevis pin (the end with a cotter pin hole) is pointing outboard and the small end of the second clevis pin is pointing aft. The sear is then inserted fully into its hole. A slight tap may be required to fully insert the sear into the two detents of its receptacle.

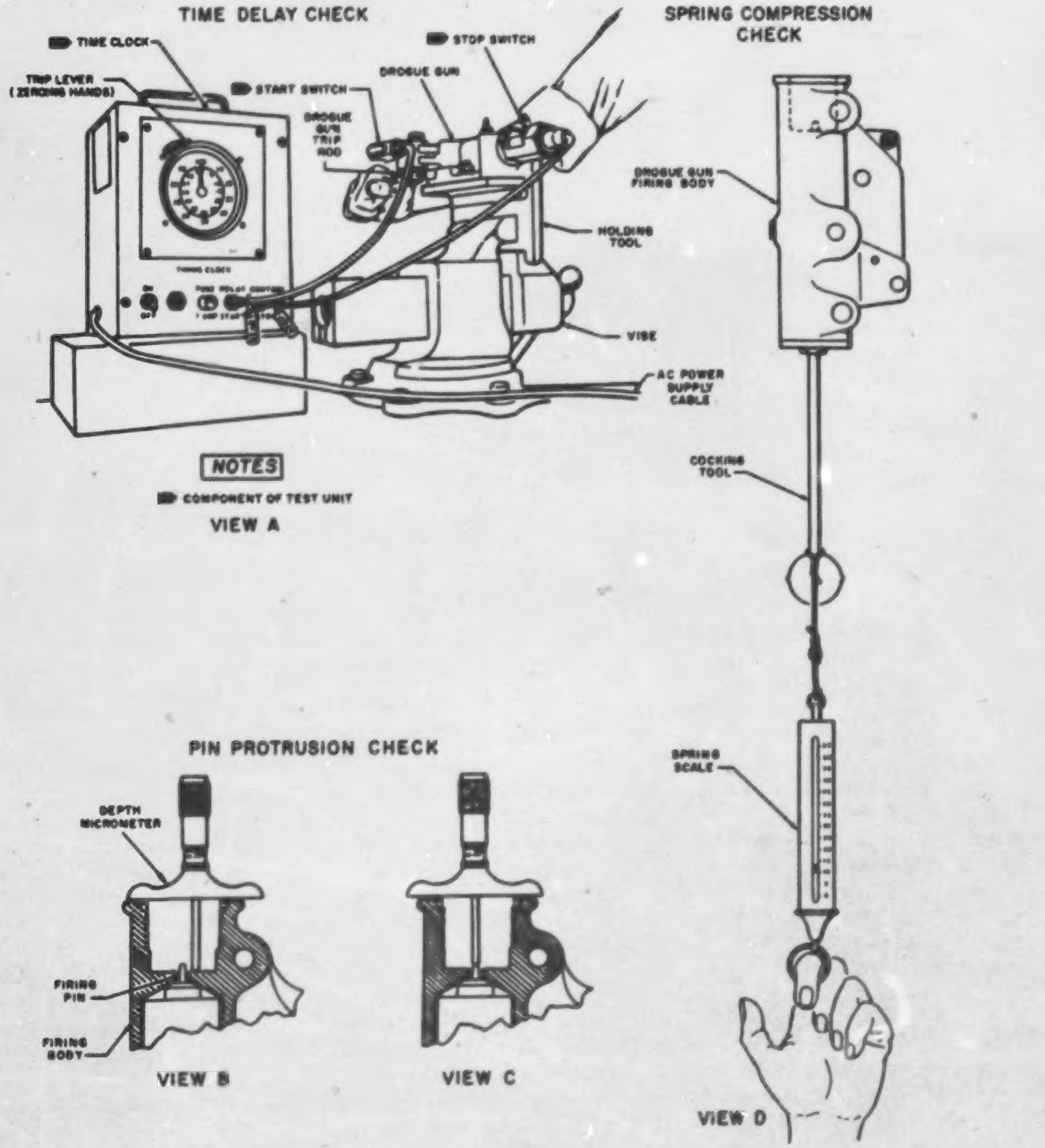
NOTE: If the sear is not fully seated or the clevis pins are not positioned as above, a semicocked condition can result which can cause inadvertent firing of the time release mechanism.

With the cocking tool installed on the time release mechanism as illustrated in figure 9-29, insert the cocking pin into the hole provided in the lower end of the rack plunger and cock the rack plunger by pushing down on the cocking tool lever until the plunger retracts as far as it will go into the housing mechanism.

Slowly release the tension on the handle. After approximately 1/4-inch return travel, the rack plunger should lock in the retracted position.

Remove the cocking pin from the rack plunger and insert it into the shackle release plunger cocking hole. Cock the shackle release plunger by pushing down on the cocking tool handle as far as it will go. The plunger will retract and an audible locking click will be heard. Simultaneously the locking pin inserted through the scissor release plunger will be forced out, if installed. (See fig. 9-29.) Release the tension on the cocking lever and after a short return motion, the shackle plunger should lock into the retracted position. Remove the cocking pin from the plunger cocking hole.

With the time release mechanism cocked and hand tension applied to the leg restraint cords, lap belt, and loop straps, push down on the harness release lever (located on the right side of the seat under the time release mechanism)


TIME DELAY CHECK
TIME CLOCK
TRIP LEVER (ZEROING HANDS)
START SWITCH
DROGUE GUN TRIP ROD
DROGUE GUN
STOP SWITCH
HOLDING TOOL
VISE
AC POWER SUPPLY CABLE
NOTES
COMPONENT OF TEST UNIT
VIEW A
SPRING COMPRESSION CHECK
DROGUE GUN FIRING BODY
COCKING TOOL
SPRING SCALE
VIEW D
PIN PROTRUSION CHECK
DEPTH MICROMETER
FIRING PIN
FIRING BODY
VIEW B
VIEW C

AM.1187

Figure 9-27.—Drogue gun checkout.

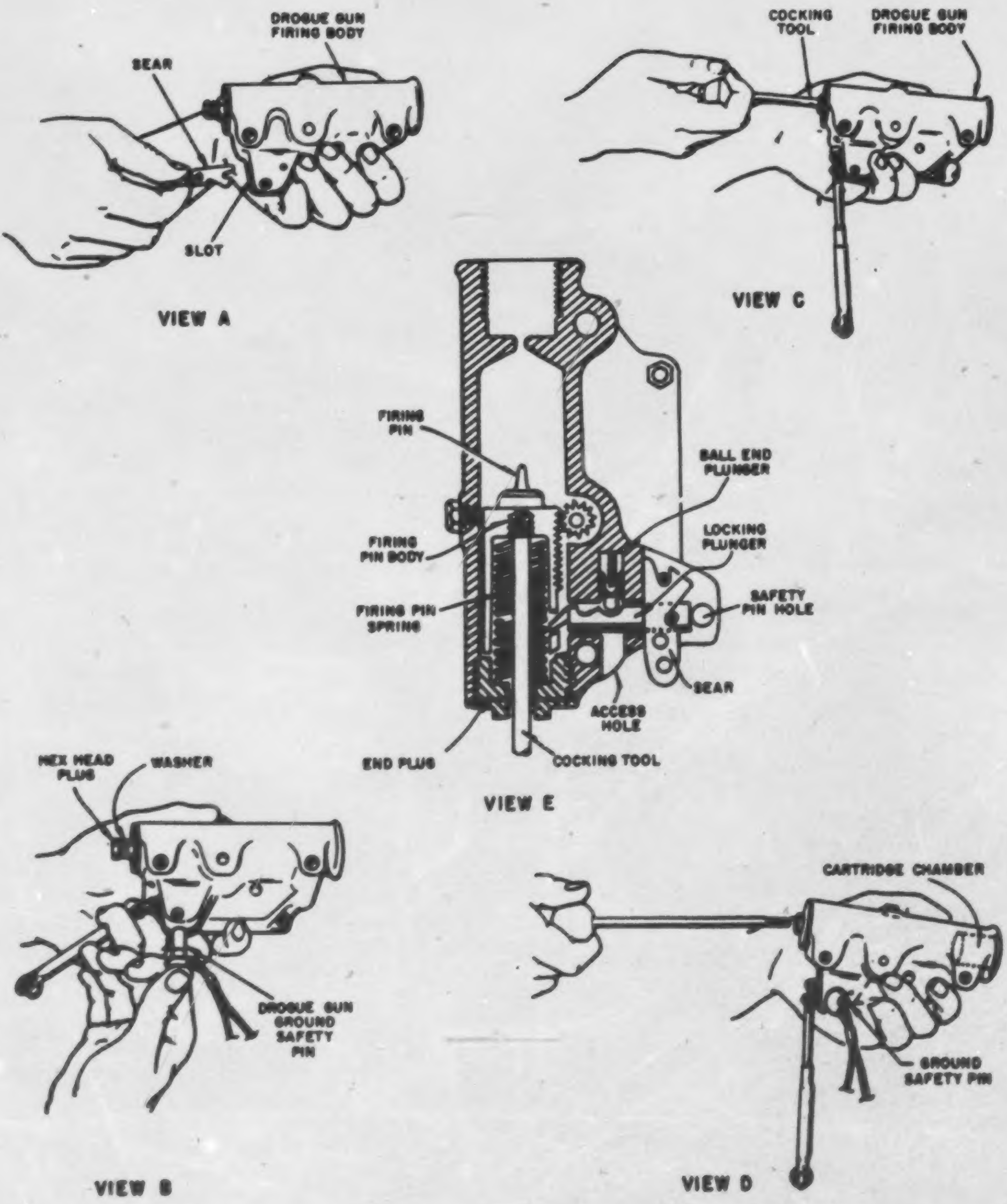

DROGUE GUN FIRING BODY
SEAR
SLOT
VIEW A
COCKING TOOL
DROGUE GUN FIRING BODY
VIEW C
FIRING PIN
BALL END PLUNGER
LOCKING PLUNGER
FIRING PIN BODY
SAFETY PIN HOLE
FIRING PIN SPRING
SEAR
ACCESS HOLE
END PLUG
COCKING TOOL
VIEW E
HEX HEAD PLUG
WASHER
CARTRIDGE CHAMBER
DROGUE GUN GROUND SAFETY PIN
GROUND SAFETY PIN
VIEW B
VIEW D

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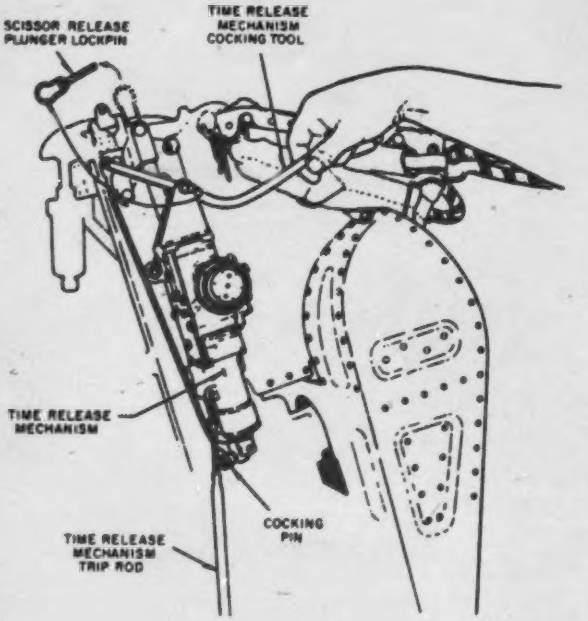
Figure 9-28.—Drogue gun cocking procedure.


SCISSOR RELEASE PLUNGER LOCKPIN
TIME RELEASE MECHANISM COCKING TOOL
TIME RELEASE MECHANISM
COCKING PIN
TIME RELEASE MECHANISM TRIP ROD

AM.1189
Figure 9-29.—Cocking the shackle release plunger.

until the leg restraints, lap belt, and loop straps release from the seat. All three should release simultaneously. On some seats, simultaneous release of all straps and cords might not occur. In such cases, insure that the leg restraints release before the lap belt and that the loop straps release after the lap belt. In any case there should not be a wide variation in the release of all cords and straps. Repeat this check at least twice to insure positive results.

Next, reconnect the leg restraint cords, loop straps, and lap belt and disconnect the guillotine firing mechanism from the emergency harness release handle.

With hand tension applied to the leg restraint cords, lap belt, and shoulder harness loop straps, depress the trigger of the emergency harness release handle (fig. 9-18) and slowly pull the handle upwards as far as it will go. The straps, restrain cords, and lap belt should all release from the seat and the handle should lock in the UP position. Insure that the lap belt and leg restraint cords release from each side of the seat evenly. The leg restraints should release before the lap belt, and the loop straps should release simultaneously with the lap belt or slightly before.

When the check is completed, place the release handle in the down and locked position, reinstall the harness, lap belt, and leg restraint cords, and connect the guillotine sear to the emergency release handle. If the guillotine cartridge is installed, insure that the safety pin is installed to prevent inadvertent firing.

Sticker Clip Tension Check.—Install the sticker strap lugs of the harness in the sticker clips on both sides of the seat bucket.

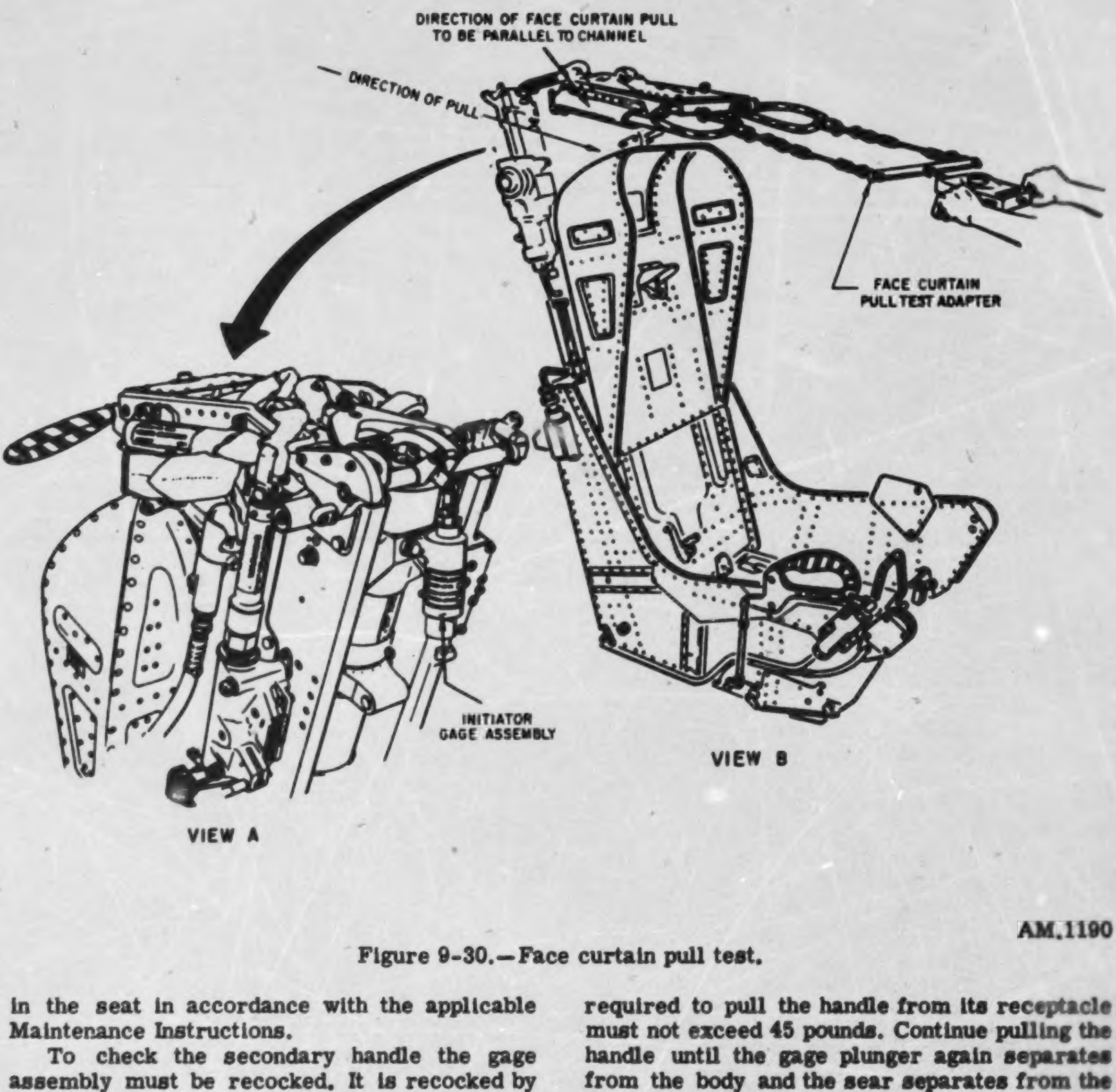
Check the tension of each sticker clip by attaching a 0-100-pound spring scale to the lug and applying tension until the lug breaks free of the clip. The breakout force for the H-7 ejection seat sticker clips is between 60 and 70 pounds.

Face Curtain and Secondary Ejection Handle Check.—Install the catapult gun on the ejection seat and install the catapult firing mechanism in the gun breech. Insure that the primary cartridge is removed. An initiator gage assembly is installed in the place of the seat initiator as shown in figure 9-30, view A. Insure that the initiator gage assembly is calibrated to provide a release load of 40 to 44 pounds prior to installing. The gage assembly simulates the initiator in checking this portion of the operation of the emergency ejection system. Connect the initiator firing links to the gage assembly and install a spare canopy interlock block in the interlock mechanism.

Attach a 0-100 pound spring scale to the face curtain handle and pull the scale, as shown in figure 9-30, view B, until the face curtain breaks away from the seat. Observe the scale reading at the time of breakaway. The force required to pull the handle from the seat should be between 50 and 70 pounds.

Continue pulling the face curtain until the gage plunger separates from the gage body. Remove the canopy interlock block from the interlock mechanism and continue pulling the face curtain until the sear separates from the catapult gun firing mechanism.

If the face curtain firing mechanism is not operating properly, the gage plunger will not separate from the firing linkage as it should. If the foregoing test conditions can not be satisfactorily completed, the mechanism should be checked for alignment, a defective gage assembly, or a bent cross shaft. DO NOT bend the initiator firing links or shorten them in any way to achieve proper gage plunger separation. When the check is satisfactory, repack the face curtain


DIRECTION OF FACE CURTAIN PULL TO BE PARALLEL TO CHANNEL
DIRECTION OF PULL
FACE CURTAIN PULL TEST ADAPTER
INITIATOR GAGE ASSEMBLY
VIEW B
VIEW A

AM.1190

Figure 9-30.—Face curtain pull test.

in the seat in accordance with the applicable Maintenance Instructions.

To check the secondary handle the gage assembly must be recocked. It is recocked by pushing up on the stem of the piston at the lower end of the gage until it is bottomed. Insert the gage plunger in the top of the gage, then release pressure on the piston stem.

When the gage assembly is recocked, reinstall the sear in the firing mechanism, connect the banana links to the sear, and attach the spring scale to the secondary ejection handle. Rotate the handle guard downward and pull the handle upward with the spring scale. The force required to pull the handle from its receptacle must not exceed 45 pounds. Continue pulling the handle until the gage plunger again separates from the body and the sear separates from the firing pin as previously described. The force required throughout the check must not exceed 45 pounds on the spring scale.

The test must be repeated three times with the seat in the middle, full down, and full up positions as directed in the applicable MIM.

When the test is complete, place the secondary ejection handle in its receptacle, place the guard up, and remove the gage assembly.

Harness Takeup Mechanism Check.—This check is with the seat in the full up position. Push the shoulder harness snubber release handle (fig. 9-10 B) all the way aft then forward to the center position. Extend the harness straps completely, then allow them to rewind about 2 inches. Place the release handle forward and attempt pulling out on the straps. They should be held securely by the snubber. Release tension on the straps and allow them to retract approximately 3 inches and repeat the procedure. Repeat these procedures until the straps are fully retracted.

Manually push the snubber (on the takeup mechanism) backward as far as possible and partially extend the harness. Release the snubber and apply tension to the strap. The snubber should return to the snub position and hold the strap from extending.

Pull the release handle aft and allow it to return to the center position. The snubber should remain in the release position with the harness loop straps free to extend and retract. Manually push the snubber to the grip position and apply tension to the straps. Hold this tension and measure the clearance between the forward faces on the dogs on the snubber unit. It is acceptable to push lightly aft on the dogs to insure that the minimum clearnace of 0.005 inch is available.

Repeat the harness takeup mechanism check with the seat bucket in the middle and full down positions. During the test, check the condition of the strap. It should be free of cuts, fraying, deterioration, thickening, and extreme discoloration.

To check the harness loop strap reel tension, place the harness release handle in the aft, then center position. Fully extend the strap and manually wind the reel in the same direction until it is fully tight. The reel should have 1 to 1 1/2 turns overtravel. When released, the loop strap should rewind completely.

Leg Restraint Mechanism Check.—Check the leg restraint cord mechanism for cracks, wear, and corrosion. The restraint cords should be inspected for cuts, wear, fraying, mildew, or deterioration, any of which could be a reason for replacement.

Check the action of the snubber by pulling forward on the restraint cord. With tension applied to the cord, check the releasing action by pulling out on the snubber finger ring until the cord releases. When released, the cord should pull out without signs of abnormal binding or drag.

To check the operation of the leg restraint manual release, place the handle (fig. 9-10 (B)) in the forward (locked) position. Insert the cord lockpins in the lockpin receptacles and insure that the pins are held securely. Pull the manual release handle aft and check to see that the cord lockpin releases from the receptacle.

Rocket Motor Installation.—Check the condition of the rocket motor propellant tubes and the firing mechanism lanyard for proper routing and installation.

Guillotine Mechanism Check.—During the calendar inspection of the ejection seat, the guillotine firing mechanism is checked for proper operation and the spring tension of the guillotine door is checked for correct tension.

To check out the firing mechanism, it is removed from the seat and inspected for corrosion, cleanliness, and condition of threads. It is then placed in a vise. Using the same firing pin extractor tool that was used on the catapult firing mechanism, lift the firing pin and remove the sear. There should be no abnormal binding of either the firing pin or the sear during the removal of the sear and pulling on the firing pin.

With the sear removed from the mechanism, attach a spring scale (0-25 pound) to the extractor tool and connect the tool to the firing pin. Pull upward on the spring scale and observe the reading on the scale when the firing pin starts to move upward. The spring tension must read between 8 and 12 pounds.

With the firing pin protruding from the lower end of the mechanism, measure the pin protrusion with a depth micrometer in the same manner as was utilized for the drogue gun. The pin should protrude the amount specified in the applicable Maintenance Instructions Manual (in this case 0.094 to 0.140 inch). If either part of the test is unsatisfactory the guillotine assembly can be repaired and returned to satisfactory condition.

To check out the guillotine knife assembly, disconnect the personnel parachute withdrawal line (link line) and remove the line from the assembly. Cut the lockwire and remove the flexible hose from the bottom of the assembly. Remove the guillotine cutter mechanism from the seat, taking care not to force the piston cutter blade assembly up with the guillotine assembled. Forcing the cutter blade assembly up and over the detent plunger could produce a burr on the plunger that can result in a guillotine "locked shut" condition.

Remove the guillotine from the seat, disassemble it, and inspect all parts for corrosion, cracks, and distortion. Inspect the piston cutter plunger and blade for freedom of burrs.

The guillotine is reassembled in the reverse order of disassembly. Lubricate the blade and piston with specified grease. Replace the hose and lockwire it securely. Route the parachute withdrawal line through the assembly and connect the line at the quick-disconnect coupling.

Attach a spring scale (0-10 pounds) to the top of the guillotine trap door. Pull the door with the scale and observe the reading on the scale when the door just begins to open. The door spring tension must be between 2 and 3 1/2 pounds as specified in the MIM.

Scissor Mechanism Check.—For this check, the time release mechanism must be cocked. Using a feeler gage, check the clearance between the jaws of the scissors for a clearance of between 0.010 to 0.050 inch.

Next, place the scissors in a vertical position and attach a spring scale to the top of the scissors. Pull straight forward on the spring scale and observe the force reading required to begin rotating the scissors forward.

The force required must be between 5 and 15 pounds. Special shims are added or removed as necessary to the scissor securing bolts until the proper scissor force is obtained. Refer to the applicable Illustrated Parts Breakdown for the part number of the proper shim material.

MARTIN-BAKER EJECTION SEAT (MK GRU-7)

The Martin-Baker GRU-7 ejection seat used in the A-6E aircraft is a conversion of the Martin-Baker MK-5 seat. The conversion has been accomplished to offer zero-zero capability at reduced g loads in the same manner as the MK H-7 seat used in the F-4 aircraft. Figure 9-31 illustrates the MK-GRU7 Rocket catapult ejection seat.

Thrust to successfully recover the occupant in the old generation seat was provided by the ballistics catapult. By supplementing the catapult with a rocket motor to sustain the trajectory the crewmember is now able to eject without being subjected to the high "G" loads previously experienced.

Description/Operation

The capability of the MK-GRU-7 ejection seat is zero-zero straight and level to 600 knots. Ejection is initiated by either the face curtain or the alternate firing handle. Linkage from both controls fire the primary catapult cartridge, which supplies energy to the ejection catapult.

After the inner and intermediate tubes of the ejection catapult gun rise 14 inches, the first auxiliary cartridge is exposed and ignited. This is accomplished by pressure in the catapult rupturing the foil disc on the inner side of the cartrige so that the heat can ignite the cartridge propellant. An additional 17 inches of travel exposes the second auxiliary cartridge and ignites it.

The rocket motor initiator firing lanyard is attached to the drogue gun trip rod and the lanyard dispenser/initiator assembly is located on the left-hand main beam assembly.

As the catapult nears the end of its stroke, the rocket motor firing lanyard is played out and actuates linkage to extract the sear of the rocket motor initiator assembly. The initiator fires, creating gas pressure which is transmitted to the pressure activated initiator attached directly to the rocket motor assembly. The pressure activated initiator ignites the rocket motor. By mounting the firing lanyard dispenser/initiator on the main beam rather than the movable seat bucket, a fixed point of rocket motor ignition has been established.

The rocket motor tubes are filled with solid rocket fuel and screwed into a manifold which contains six nozzles. The motor in addition to providing seat thrust also provides seat divergence to eliminate the possibility of seat collision in multiple ejection situations. The divergence is accomplished by the inboard rocket nozzles being slightly larger in diameter. Because of the divergent trajectory the two seats of the aircraft are not interchangeable. Doing so would cause them to collide on ejection.

The initial movement of the ejection seat also extracts the arming sear of the drogue gun. The escapement mechanism of the drogue gun establishes a time delay of 1/2 second before the gun fires. The drogue cartridge supplies enough energy to shear the piston pin and propel the piston with sufficient velocity to extract the drogue parachute system.

The drogue parachute system consists of a withdrawal line, a controller drogue parachute, a bridal or strop line, a stabilizer drogue parachute, and the drogue shackle.

The emergency oxygen system, contained in the lid of the survival kit, provides approximately

97 cubic inches of gaseous oxygen. Oxygen is supplied automatically on ejection. A lanyard from the oxygen valve to the seat personnel services disconnect activates the valve automatically on initial ejection movement.

Emergency oxygen may be selected manually by activation of the manual control located on the left-hand thigh support.

Automatic activation of the aircraft IFF equipment occurs if either seat is ejected. The seat main beam assembly activates a microswitch located on the ejection catapult which in turn activates the IFF.

Initial "g" forces of ejection cause the legs to swing down against the thigh supports and the leg restraint system leg lines restrain them there. One end of the leg lines is attached to the cockpit deck fitting. The lines are routed through the restraint snubber assembly, which prevents the lines from reeling out. The upper end of the leg lines route through the crewmembers leg garter assembly and terminate with an end fitting which is engaged in the restraint system locking mechanism.

The seat is equipped with a power type inertia reel which serves as a retention device for normal flights and provides power actuated upper torso retention on ejection as well as upper torso retention in crash circumstances. (See fig. 9-32.)

On ejection, ejection seat linkage rotates a shaft and connecting linkage which extracts the sear from the power reel firing mechanism. The cartridge fires and supplies energy via tubing to the rack shaft. The rack shaft extends and rotates a gear mechanism which in turn rotates another shaft containing the dual strap spools.

Inertia reel locks engage the end fitting of the dual inertia reel strap spools. The locking lugs are actuated by ramp type lock pin release sears attached to shafts. When the time release mechanism or the manual override handles are actuated the shafts pull down and retract the locking lugs.

The reel has a preloaded clock spring which maintains tension on the spools to retract the harness straps. With the control handle in the forward position the straps can not extend but they will retract. With the handle in the center position the straps will extend and retract.

Rapid strap extension caused by sudden forward movement will cause the strap to lock and prevent further travel until the forward tension is relieved.

In the low-level ejection sequence, the time release mechanism fires in 2 seconds. The trip rod attached to the ejection gun crossbeam extracts the time release mechanism sear on initial movement of the seat. The time release mechanism is illustrated in figure 9-33.

When the harness release plunger of the time release mechanism extends, it strikes a harness release lever. Linkage from the lever unlocks the leg restraints, lap belts, and inertia reel straps, and locks the firing controls.

A shackle release shaft is attached to the opposite end of the harness release plunger. This shaft locks the scissor shackle, which secures the drogue parachute to the seat structure for seat stabilization during the ejection sequence. When the shackle release retracts on extension of the harness release plunger, the scissor shackle opens and the drogue parachutes are released from the seat and are free to deploy the personnel parachute. The drogue parachutes pull link pins which release the face curtain restraint straps and extract the main personnel parachute withdrawal line from the guillotine and pull the chute out of its pack.

On ejections above 14,500 feet the time release mechanism is locked out by the barostat assembly. The occupant is locked in the seat by his restraints and stabilized by the drogue parachutes until he descends to an altitude between 14,500 and 11,500 feet.

The lap belt assembly is equipped with two sticker clip lugs which engage the spring-loaded sticker clips on each side of the seat bucket. During separation from the seat on ejection, the sticker clips provide enough friction to cause the upper seat structure to rotate away from the occupant. This rotation insures there is no seat/man collision.

The manual override handle located on the right hand side of the seat bucket permits the occupant to override the automatic release system in the event of a malfunction. Actuation of this handle fires the guillotine to cut the parachute withdrawal line and unlocks the leg restraint lines, the lap belt, and inertia reel straps, and the sticker clips.

If this handle is used in lieu of automatic separation the occupant must release his personnel parachute manually by pulling the ripcord handle. Actuation of the manual override handle also locks the firing control handles in whatever position they are in on actuation. This function aids the occupant and/or crash crews in making an emergency egress following a crash or because

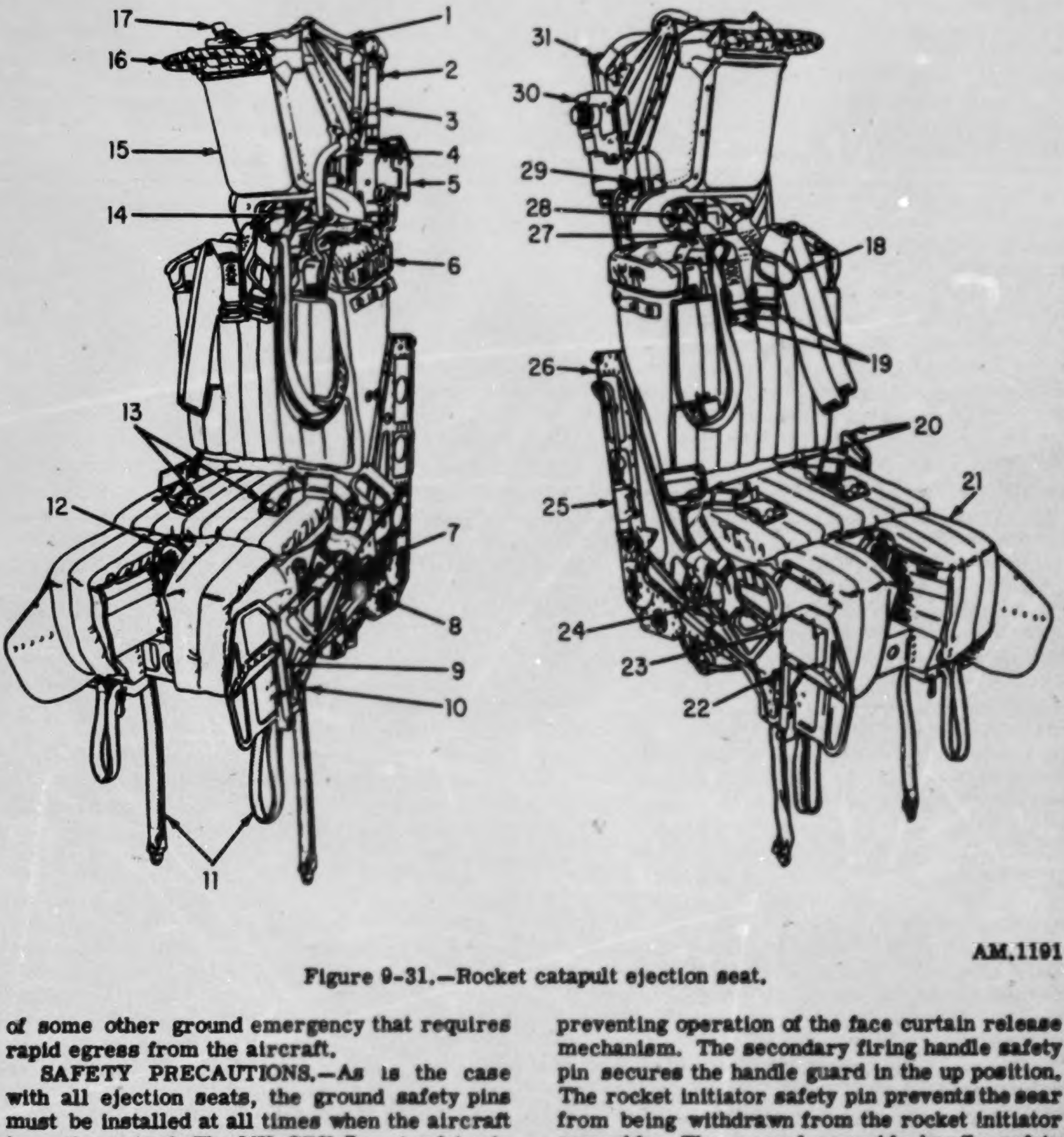


Figure 9-31.—Rocket catapult ejection seat.

of some other ground emergency that requires rapid egress from the aircraft.

SAFETY PRECAUTIONS.—As is the case with all ejection seats, the ground safety pins must be installed at all times when the aircraft is on the ground. The MK-GRU-7 seat safety pin assembly is equipped with 6 pins with flags.

The ejection gun safety pin prevents the sear from being pulled on the catapult firing mechanism. The drogue gun pin prevents the sear from being pulled from its firing body. The face curtain lock pin secures the face curtain lock, preventing operation of the face curtain release mechanism. The secondary firing handle safety pin secures the handle guard in the up position. The rocket initiator safety pin prevents the sear from being withdrawn from the rocket initiator assembly. The manual override handle safety pin prevents the handle from being rotated to the release position, which would fire the guillotine and release the various restraint mechanisms.

The ejection seat safety precautions discussed previously have application to most

Nomenclature for Figure 9-31.

1. Drogue withdrawal line.
2. Top latch mechanism.
3. Drogue gun.
4. Guillotine unit.
5. Rocket motor firing unit.
6. Personnel parachute.
7. Stowage clip (2).
8. Shoulder harness release lever.
9. Left leg restraint line release lever.
10. Survival kit front release lever.
11. Leg restraint lines (2).
12. Secondary firing handle.
13. Lower restraint harness Koch fittings (2).
14. Power retraction unit.
15. Headrest.
16. Face curtain (primary) firing handle.
17. Face curtain lock.
18. Personnel parachute D ring.
19. Upper restraint harness Koch fittings (2).
20. Survival kit release handles (2).
21. Survival kit.
22. Right leg restraint line release lever.
23. Switch housing (seat raise and lower, seat tilt).
24. Manual override handle.
25. Guillotine breech.
26. Seat bucket.
27. Upper restraint harness.
28. Upper restraint harness roller fittings (2).
29. Power retraction breech.
30. Time release mechanism.
31. Shackle retaining plunger assembly.

ejection seats. Prior to working on any ejection system the AME must have complete knowledge of the peculiarities or specific hazards inherent to that particular ejection system. Personnel must not attempt to perform tasks for which they are not qualified.

Components

The coverage of the MK-GRU-7 ejection seat components in this section will include maintenance considerations.

EJECTION GUN AND PRIMARY FIRING MECHANISM.—The ejection gun is almost identical to the one used with the MK-H-7 of the F-4 aircraft.

The outer tube contains the guide rails, auxiliary cartridge housings, upper and lower structural support mountings, a safety latch through which the top latch mechanism engages, structural steel inserts to engage the top and bottom seat main slippers, and an interference plate.

The intermediate tube is equipped with 12 gas filled snubber rings and 12 piston rings (2 sets of 6). A carrier ring beneath the snubber rings gives an even bearing surface against the rings during the catapult stroke. The piston rings are installed with their end gaps staggered so that effective sealing will not be lost. The inner tube guide bushing is riveted to the top of the intermediate tube with two special value rivets.

The inner tube is equipped with 6 piston rings. A breech for the firing mechanism is screwed into the top of the tube and secured by a rivet. The breech has slots which engage the dowel pin on the top crossbeam and prevent rotation of the inner tube assembly when torquing the firing mechanism into the breech.

An intermediate tube guide bushing is screwed into the top of the outer tube (cylinder barrel) and secured to the barrel with a special dowel screw. During the ejection sequence this bushing retains the 12 gas filled snubber rings.

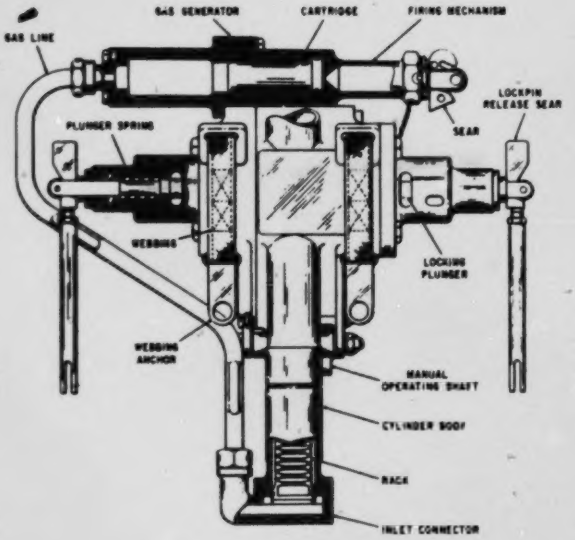
The primary firing mechanism consists of the firing pin, a spring, a ramp type sear, firing body, a water seal, and a tab washer.

During the catapult stroke, the intermediate tube is stopped by the snubber rings being compressed between the piston end and the intermediate tube guide bushing. The inner tube continues to rise and the inner tube lower end strikes the inner tube guide bushing, shearing its two rivets. The bushing and inner tube leave the ejection gun with the seat.

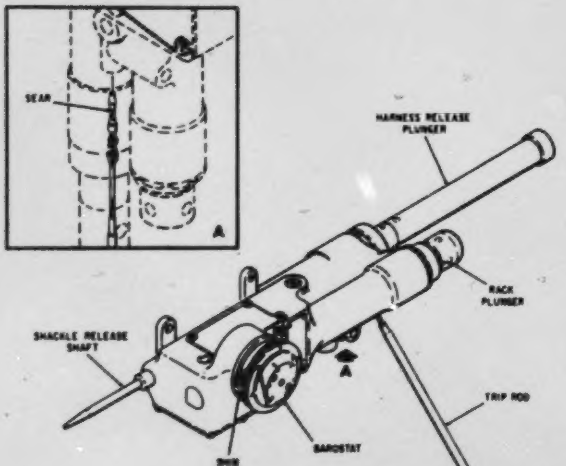
Maintenance of the catapult and firing mechanism during the calendar inspection is similar to that previously discussed. Firing pin spring tension and pin protrusion measurement are provided in the applicable MIM.

When the firing mechanism is removed from the catapult gun for maintenance, a plastic bag should be installed over the top of the gun to prevent contamination.

When replacing the intermediate guide bushing during reassembly of the catapult gun, grade E Locktite should be applied to the threads of the dowel screw to prevent the screw from


GAS LINE
GAS GENERATOR
CARTRIDGE
FIRING MECHANISM
LOCKPIN RELEASE SEAR
SEAR
PLUNGER SPRING
WEBBING
LOCKING PLUNGER
WEBBING ANCHOR
MANUAL OPERATING SHAFT
CYLINDER BODY
RACK
INLET CONNECTOR

AM.1192
Figure 9-32.—Power inertia reel—A-6E.


SEAR
A
HARNESS RELEASE PLUNGER
RACK PLUNGER
SHACKLE RELEASE SHAFT
A
TRIP ROD
BAROSTAT
SHIM

AM.1193
Figure 9-33.—Time release mechanism.

backing out. Locktite is the trade name of a friction producing liquid.

TIME RELEASE MECHANISM.—The time release escapement mechanism with its rack shaft plunger, shackle release shaft, and barostat assembly operates in the same manner as the time release mechanism for the MK-H-7 ejection seat with the exception of the scissor release shaft. This shaft (fig. 9-33) is integrated to the harness release plunger. When the plunger releases, the scissor release shaft is withdrawn from the bushing that locks the scissors holding the drogue parachute system to the seat structure, and the scissors open.

The time release is cocked in the same manner as was previously discussed. A release mechanism assembly check is accomplished as follows.

With the time release mechanism mounted on its holding fixture and the holding fixture in a vise, cock the rack and harness release plungers (sear is installed). Move the rack shaft to its overtravel position and release tension. It should return to its normal cocked position. Pull the sear from the time release body and allow the shackle harness release plunger to extend slowly by restraining it with the cocking tool.

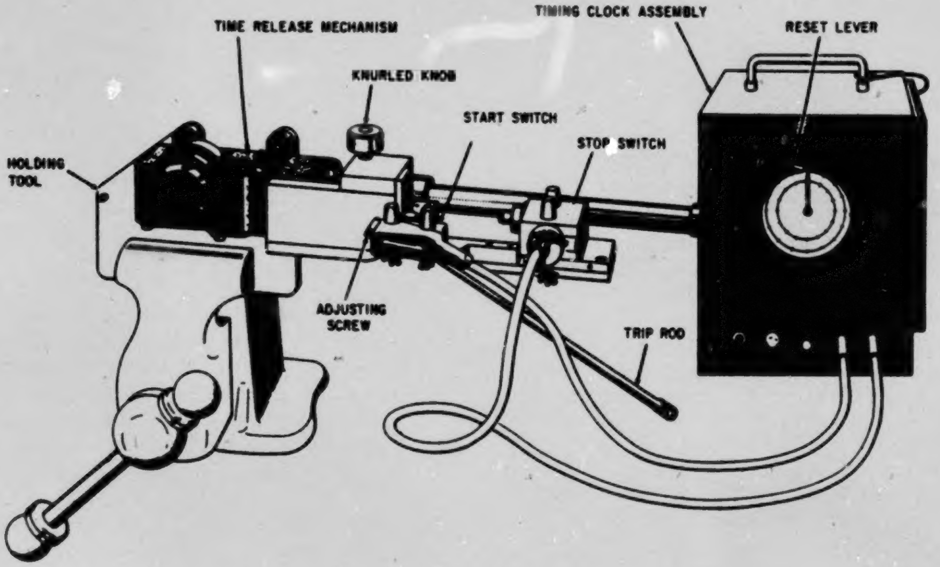
Time Delay Check.—The time delay check and the barostat check must be conducted as two separate checks. Release of the barostat can create an erroneous time delay reading.

Insert the sear fully into the time release mechanism and cock the rack shaft. Attach the time release start and stop switches, as shown in figure 9-34, and tighten the knurled stud. Connect the stop-start leads into their respective jacks on the time clock assembly. Place the switch to the ON position. The power indicator light should light. Make sure the start microswitch is adjusted properly against the shoulder of the rack shaft. Fine adjustment can be made with the adjusting screw vice the mounting bolts.

Next, reset the clock assembly to zero by depressing the reset lever. Pull the sear from the mechanism. The clock should indicate between 1.90 to 2.10 seconds. Perform the check three times.

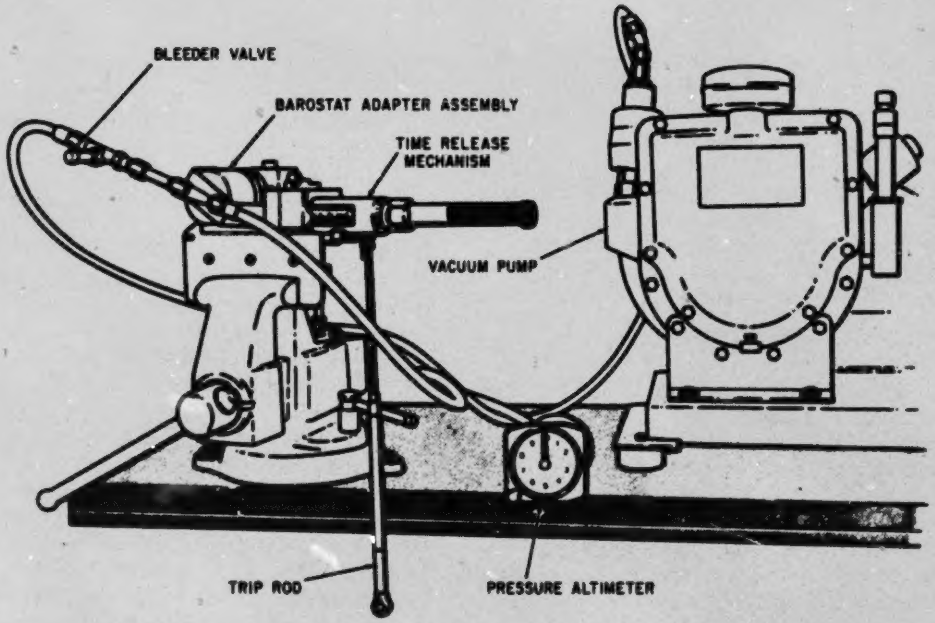
Barostat Check.—Mount the time release mechanism in the holding fixture and secure it in a vise as shown in figure 9-35. Insert the sear and cock the rack plunger only.

Connect the barostat vacuum adapter fitting to a vacuum source with a pressure altimeter hose attached to a bleeder tee valve assembly. Remove the lockwire from the barostat and


TIME RELEASE MECHANISM
TIMING CLOCK ASSEMBLY
RESET LEVER
KNURLED KNOB
START SWITCH
STOP SWITCH
HOLDING TOOL
ADJUSTING SCREW
TRIP ROD

AM.1194

Figure 9-34.—Time delay check.


BLEEDER VALVE
BAROSTAT ADAPTER ASSEMBLY
TIME RELEASE MECHANISM
VACUUM PUMP
TRIP ROD
PRESSURE ALTIMETER

AM.1195

Figure 9-35.—Time release barostat check.

install the adapter over the barostat assembly. Set the altimeter to field barometric reading, then close the bleeder valve.

Slowly apply vacuum until the altimeter indicates 16,000 feet. Maintain this reading and pull the sear.

The escape mechanism should not run. Open the bleeder valve and slowly reduce vacuum. The actuation altitude must be between 14,500 and 11,500 feet as was the case with the MK-H-7 seat. Reduce the vacuum to field barometric pressure. Perform this check a total of three times to insure positive results.

When the check is complete, Quality Assurance must lockwire the barostat cover and affix a lead seal.

DROGUE GUN.—The drogue gun of the MK-GRU-7 seat is identical in operation and maintenance considerations as the drogue gun of the MK-H-7 seat discussed previously with the following exceptions.

The drogue gun has a blanking bolt in place of a cocking indicator, and the firing body contains a safety sleeve assembly. The safety sleeve's function is to provide mechanical interference, with the firing pin in the fired position. This prevents installation of the ground safety pin unless the gun is properly cocked and the locking plunger is engaged in the firing pin hole. This also prevents the installation of a cartridge on a protruding firing pin unless the maintenance man completely ignores arming procedures.

The time delay run time for the MK-GRU-7 drogue gun is between 0.4 and 0.6 second.

NOTE: When reassembling the drogue piston assembly, avoid excessive lubrication of the piston as hydraulic locking could prevent the piston from going into the barrel far enough to get the shear pin in. (See fig. 9-22.)

POWER REEL MECHANISM.—Maintenance of the power inertia reel during the calendar inspection includes an operational check and a firing mechanism check.

To perform the operational check, actuate the control lever to aft and then forward to the center (auto-lock) position. Grasp each strap in turn and pull out to full extension. The opposite strap should automatically reel out also. The straps should pull out without any binding or drag except that created by the reel's spring tension. Insure that they retract fully. Partially withdraw the straps then accelerate the movement and see if the clutch comes into operation and prevents further withdrawal until tension is relieved.

Fully withdraw the straps and place the control lever to the full forward (locked) position. Allow the straps to retract slowly, checking at intervals that all forward movement is prevented.

While the straps are fully extended, inspect their condition. If the straps require replacement, the inertia reel must be removed from the seat.

Reel Firing Mechanism Check.—The load required to extract the sear from the power inertia reel firing mechanism must be between 7 and 13 pounds. With the firing mechanism secured vertically in a vise (sear upward) attach a spring balance to the sear by means of a short lanyard. Apply a load on the spring balance at right angles to the centerline of the firing pin.

The pin protrusion check and the firing spring compression check are performed as previously discussed.

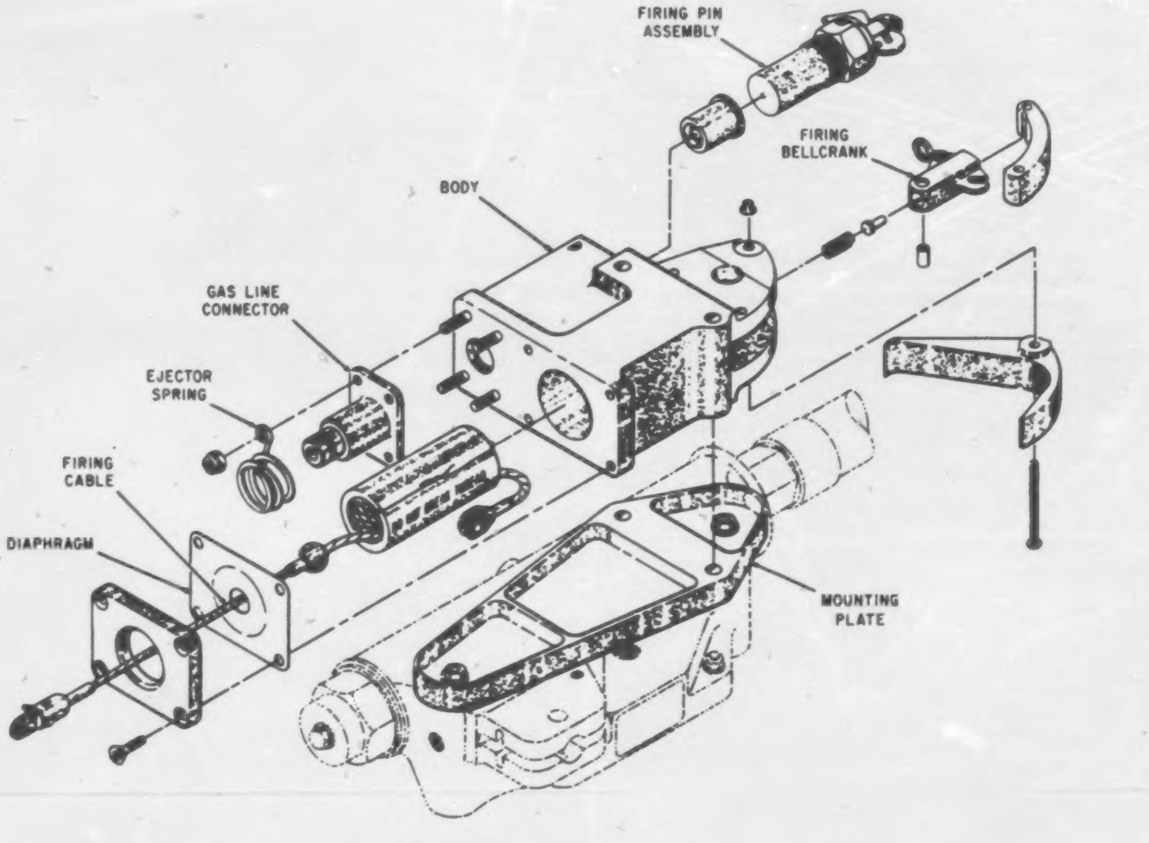
GUILLOTINE MECHANISM.—The sear extraction load check of the guillotine firing mechanism is performed in the same manner as the inertia reel firing mechanism was conducted except the load required to extract the sear must be between 15 and 25 pounds.

The pin protrusion and spring compression checks are performed in the same manner as for the guillotine of the MK-H-7 seat.

The door mechanism check for the guillotine is expanded to include checking the door spring tension with the door at the "near full open" position. This portion of the door check is performed by pulling the door to the fully opened position with the attached spring scale. Then, relax the pull so that start return motion of the door is observed. Load measured at this point shall not exceed 8 pounds.

ROCKET MOTOR INITIATOR.—The rocket motor initiator contains a cable dispenser and a firing mechanism. (See fig. 9-36.) One end of the firing cable connects to the firing bellcrank. The other end terminates at the drogue gun trip rod assembly.

When the ejection seat is fired the drogue gun trip rod stays with the aircraft and the cable feeds out of the dispenser. At approximately 10 to 12 inches before the seat separates from the catapult rails, the cable is stretched tight and rotates the bellcrank which, in turn, removes the sear from the cartridge firing mechanism. The gas pressure is transmitted to the rocket motor integrated initiator, causing its shear pin to fail and the motor initiator to fire.



AM.1196

Figure 9-36.—Rocket motor initiator.

During calendar inspection the rocket motor initiator is removed from the seat and subjected to inspection and check of the firing mechanism. The initiator must be dearmed prior to removal.

With the firing pin assembly removed from the initiator assembly and placed in a vise, remove the sear using a firing pin extractor tool. Release the firing pin and allow the firing pin to protrude from the base of the firing pin body. Place the protrusion gage over the firing pin and insure that the end of the gage is in total contact with the base.

Hold the gage in contact with the base and push the gage plunger until it makes contact with the firing pin. The pin protrusion should be between 0.94 and 0.140 inch as specified in the applicable Maintenance Instructions Manual.

Use a spring scale and check the firing mechanism spring tension. Tension must be at least 8 pounds. Reinsert the sear and check that the firing pin is not protruding from the base of the body.

NOTE: The rocket motor is a sealed unit and no attempt must be made to remove the gas operated initiator or igniter cartridge.

ROCKET MOTOR REMOVAL AND INSTALLATION.—To remove the rocket motor from the ejection seat, remove the lockwire securing the flexible hose nut to the rocket motor tube. Disconnect the hose from the gas-operated initiator and remove the spring clip attaching the hose to the rocket tube. Remove the lockwire from the rocket mount bolts. Support the rocket motor and remove the bolts.

WARNING: The rocket motor contains approximately 6 1/2 pounds of propellant and a percussion fired igniter cartridge. Handle the motor carefully and do not drop. The removed rocket motor should be handled, stored, and/or disposed of in accordance with NavAir 11-85-1.

A preinstallation inspection of a new rocket motor includes visually inspecting the motor for signs of damage, distortion, and corrosion. Insure that all lockwire and lead seals called for are intact and unbroken and that a plastic cover is fitted to each efflux nozzle. If any of these conditions are not satisfactory the rocket motor should be replaced.

Check the rocket motor service expiration date and record this date for entry in the aircraft logbook.

Locate the cam follower into the inclined track, align the bolt holes, and install and torque the bolts in accordance with the MIM. Lockwire the attachment bolts and connect the flexible gas hose to the firing unit; torque and lockwire. Locate the flexible hose spring clip over the correct rocket motor tube.

The rocket motor cam follower arm rotates the rocket pack as the seat bucket position changes. This results in the rocket nozzle direction changing to compensate for a center of gravity shift caused by the repositioned seat bucket.

Ejection Seat Calibration and Functional Testing

The functional testing of the restraint system of the MK-GRU-7 seat parallels that performed on the MK-H-7 seat discussed previously. The spring scale readings for the face curtain check, the sticker clip tension check, etc. may vary between different model ejection seats. Strict compliance with the steps in the applicable Maintenance Instructions Manual will prevent the use of erroneous readings. The measurements, readings, and information provided in this manual should not be used in performing maintenance.

The MK-GRU-7 ejection seat must be calibrated to the ejection gun on which it is installed. Calibration refers to the clearance between the ends of the slippers on the seat main beams and the ejection gun rails.

The slippers may be moved in or out by adding shims or spotfacing to achieve the required clearance. The top slippers must have between 0.001 and 0.006 inch clearance at their respective location on the ejection gun rails. The middle slipper must have 0.005 to 0.030 inch clearance, and the lower slippers must have 0.000 to 0.005 inch. When the clearances have been achieved, torque the slippers as specified in the applicable Maintenance Instructions Manual.

After calibrating the slippers, they must be checked for proper alignment. (See fig. 9-37.)

Using a 4-foot straightedge, align the slippers, as illustrated in figure 9-37, using a suitable wrench to make the adjustment. Proper alignment is necessary to prevent scoring of the seat rail tracks and binding.

Seat Buildup

The buildup of the MK-GRU-7 ejection seat in readying it for flight consists of installation of the drogue parachute container, face curtain, personnel parachute, survival kit, ventilated back pad assembly, seat cushion, and thigh support pads, and hook up of the emergency oxygen system.

DROGUE PARACHUTE CONTAINER INSTALLATION.—Insure that sun protective covers are installed over the drogue withdrawal lines prior to commencing installation of the drogue container.

Swing the restraint scissors to the vertical position and slide the container down into the headbox assembly.

CAUTION: The drogue container should not be installed in the headbox with the face curtain restraint straps installed, as the container can jam the straps and prevent face curtain movement.

Install the securing hardware with the heads of the bolts inside the headbox. Insure that the safety tie securing pin is installed.

With the time release fired and the scissors free to open, rotate the scissors down and engage the drogue shackle in the scissor jaws and close them. Recock the time release, thus locking the jaws closed. Tie the scissor shackle down with 50-lb, #6 safetie cord.

FACE CURTAIN INSTALLATION.—To install the face curtain, first pull the secondary firing control handle to allow the linkage from the equalizer shaft to extend forward. Connect the fittings of the face curtain firing cables to the firing links, then stow the secondary firing handle.

Fold the face curtain cloth under at each side to the width of the face curtain container. Route the restraint straps through the headbox and attach the restraint fittings to the link pins.

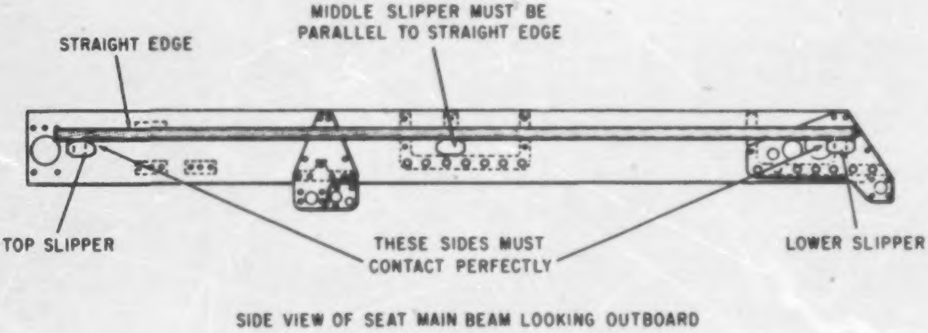

MIDDLE SLIPPER MUST BE PARALLEL TO STRAIGHT EDGE
STRAIGHT EDGE
TOP SLIPPER
THESE SIDES MUST CONTACT PERFECTLY
LOWER SLIPPER
SIDE VIEW OF SEAT MAIN BEAM LOOKING OUTBOARD
AM.1197

Figure 9-37.—Slipper alignment check.

Install the stitched aft end of the face curtain to the rear of the container. Accordian fold the face curtain into the container with the firing cable slack stowed with a single loop before the last fold. Route the cables under the cross tube of the handles.

Make sure the release pins are fully extended in the retention holes of the container and install the cross-tube section of the face curtain handle into the container. Engage the face curtain handle locking mechanism and insure that the locking pin properly engages the cross-tube.

With the face curtain locking mechanism in the "ready" position, rotate the manual override handle to insure that the locking pin again engages the face curtain crossover tube.

PERSONNEL PARACHUTE INSTALLATION.—Packing of the personnel and drogue parachutes are the responsibility of personnel within the PR rating. However, they are installed in the ejection seat by the AME.

Prior to installing the chute, insure that the repack has been accomplished by checking the inspection card. Place the parachute container on its support bracket and press the container down until both locking lugs are engaged in the locks.

Route the drogue withdrawal line through the guillotine assembly and attach the screw connector of the parachute withdrawal line to the drogue parachute link line connector screw.

Route the inertia reel straps through the riser rollers and engage the right-hand inertia reel lug in its lock. Engage the left-hand inertia reel lug and the parachute withdrawal restraint lug in the left-hand lock.

SURVIVAL KIT INSTALLATION.—With the seat bucket in the down position, rotate the lever in the rear of the seat bucket to unlock the aft bucket locking plungers. Insure that the negative "g" lock on the front of the seat bucket is engaged in the kit lock fitting. Lower the locking lever and insure both aft locking plungers engage the survival kit locking lugs.

Pull on the lap belt straps to insure the survival kit is securely locked. Engage the sticker lugs in the sticker clips. Connect the emergency oxygen lanyard to the personnel services quick-disconnect assembly on the left side of the seat bucket.

MISCELLANEOUS HOOKUPS.—The ventilated back pad, seat cushion, and thigh support pads are installed by pressing their Velcro hooks in the pile glued to the survival container cover and the seat and stitched to the parachute container. Velcro is the trade name designation of a hook and pile tape fastener constructed of woven nylon material. One-half of the tape is composed of hooks and the other half of pile loops. A connection of the hook and pile halves is completed by mating the two tape halves and applying a slight pressure to force the hooks into the pile. The tape can be pulled apart easily and stands up under repeated use.

The ventilation hose from the back pad assembly is attached to the long hose of the vent air manifold. The ventilation hose from the seat cushion is attached to the shorter hose located forward on the vent air manifold.

Seat Installation, Arming, Dearming, And Removal

Seven cartridges are installed in the MK-GRU-7 ejection seat. The primary catapult, drogue gun, guillotine, power inertia reel, and rocket motor initiator cartridges are percussion type cartridges which can fire on impact if dropped.

When removed from the ejection seat the cartridges should be stored in a cartridge block similar to the one shown in figure 9-38.

No matter how often the safety precautions for ejection seat cartridges are stressed, accident summary reports still show that personnel are mishandling them and causing serious personal injury and damage to equipment.

Prior to working on any ejection system make sure you are thoroughly checked out and aware of all special safety precautions inherent to the system.

Cartridges removed for maintenance purposes should be properly marked and stowed so that they are reinstalled in their original location. Some cartridges of ejection seat systems have the same dimensions and appearance and are physically interchangeable. Therefore, positively identify each cartridge on removal and installation to prevent improper operation, the results of which could be fatal to a crewmember who needs to use the seat in an emergency.

EJECTION GUN INSTALLATION.—Prior to installing the catapult gun check the interchangeability plate located on the blanking bolts for the correct location of the gun. Any attempt to fit the wrong seat on the ejection gun will be prevented by the stop-block at the lower end of the main beam engaging the projecting plate.

Install the ejection gun on the lower pivot block with the bolt head facing forward. Rotate the gun forward and install the water seals and auxiliary cartridges in their chambers. Using a torque wrench and adapter, torque the caps as specified in the applicable Maintenance Instructions Manual. In this case 550 inch lbs. Quality Assurance must lockwire and affix the lead seal.

Attach the IFF switch to the cross beam, then position the gun so that the attach fitting mates with the seat tilt scissor assembly and install attaching hardware.

Cycle the catapult tilt assembly through its full range of tilt before proceeding further.

Insure that the breech of the inner tube is completely down on the intermediate tube guide bushing and the main beam locating pin slot is aligned with the centerline of the safety latch opening.

ARMING THE GUILLOTINE.—Install the ground safety pin in the manual override handle, disconnect the sear from the linkage, and remove the firing mechanism.

Insert the special bonded dowdy seal and the guillotine cartridge into the firing body. Insure that the firing pin is not protruding from the firing mechanism with the sear installed. Install safety wire in the ground lock pin hole of the sear. Install the firing mechanism and torque as specified in the MIM.

Remove the safety wire from the ground lock pin hole and insert a temporary safety pin. Quality Assurance must lockwire and affix the lead seal.

ARMING THE POWER INERTIA REEL.—Remove the firing mechanism and check that the firing pin is not protruding when the sear is installed. Insert safety wire in the safety pin hole of the sear in the same manner as was done in arming the guillotine.

Place the seal on the cartridge and install in the breech. Torque the firing mechanism as specified in the MIM. Quality Assurance must lockwire and affix a lead seal.

Remove the safety wire from the safety pin hole in the sear and install a temporary safety pin. Connect the sear to the firing link.

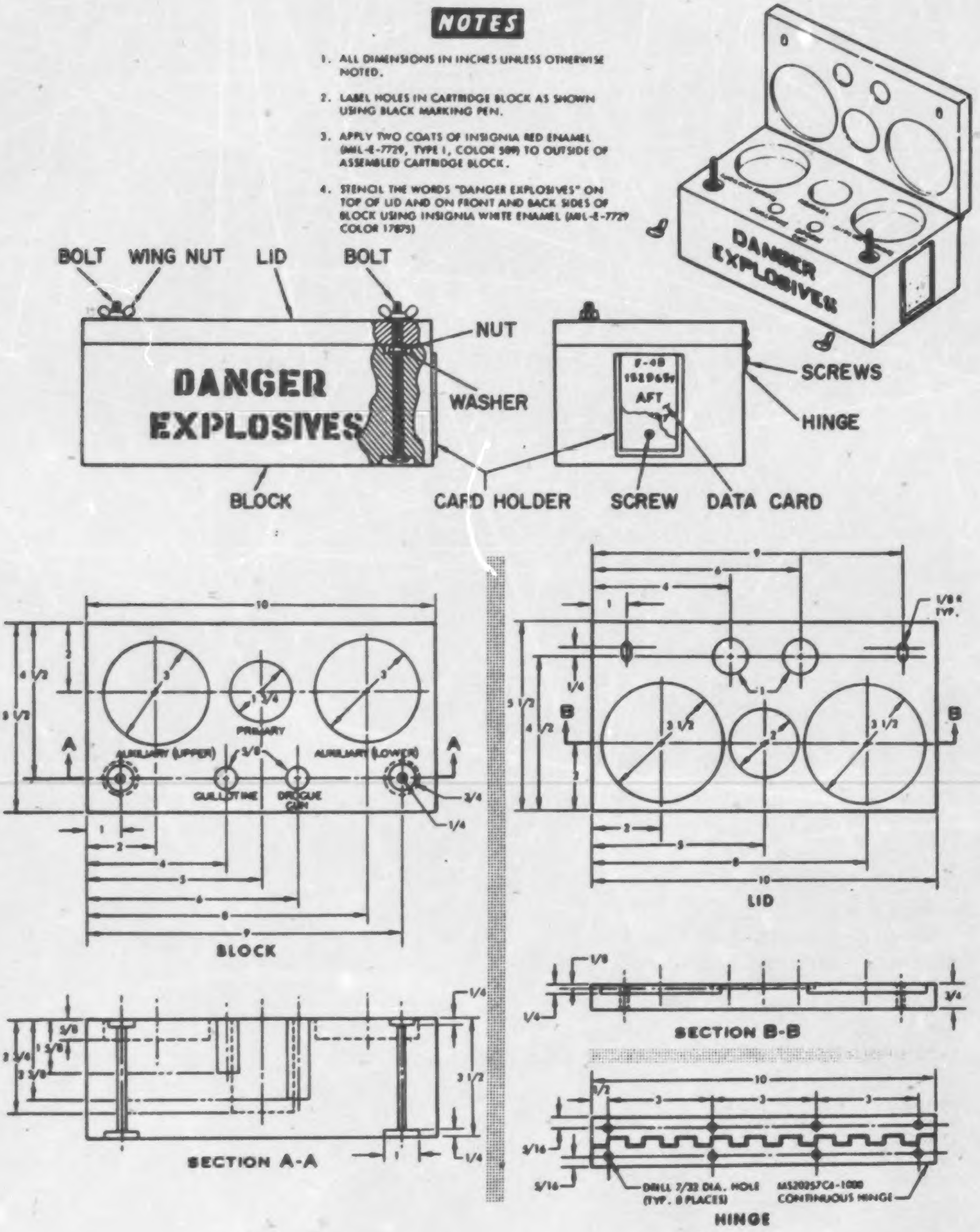
SEAT INSTALLATION.—Attach the seat hoisting sling to attachment points of the seat.

WARNING: If the seat is dropped during installation, impact could cause ignition of the rocket motor. Exercise extreme care during installation.

Attach the alignment fixture in the extended and locked position on the bottom and middle slippers of the seat main beam with the retaining pin installed on the top of the middle slipper.

Hoist the seat with alignment fixture over the breech of the ejection gun. Remove the primary firing mechanism and inner tube retainer from the catapult gun. Lower the seat and actuate the locking lever to lock the alignment fixture to the breech of the ejection gun.

Slowly lower the seat until the top slippers are just above the alignment fixture. Remove the alignment fixture retaining pin and lock pin and fold the top of the fixture. Continue lowering the seat until the middle slippers are engaged in the gun rails, then remove the alignment fixture. Fully lower the seat and remove the hoisting sling. Push down sharply to fully bottom the seat on the rails.



NOTES

1. ALL DIMENSIONS IN INCHES UNLESS OTHERWISE NOTED.
2. LABEL HOLES IN CARTRIDGE BLOCK AS SHOWN USING BLACK MARKING PEN.
3. APPLY TWO COATS OF INSIGNIA RED ENAMEL (MIL-E-7729, TYPE I, COLOR 509) TO OUTSIDE OF ASSEMBLED CARTRIDGE BLOCK.
4. STENCIL THE WORDS "DANGER EXPLOSIVES" ON TOP OF LID AND ON FRONT AND BACK SIDES OF BLOCK USING INSIGNIA WHITE ENAMEL (MIL-E-7729 COLOR 17875)

BOLT
WING NUT
LID
BOLT
NUT
DANGER EXPLOSIVES
WASHER
SCREWS
HINGE
F-4B
AFT
BLOCK
CARD HOLDER
SCREW
DATA CARD
PRIMARY
AUXILIARY (UPPER)
AUXILIARY (LOWER)
GUILLOTINE
DROGUE GUN
A
B
BLOCK
LID
1/8 R TYP.
SECTION A-A
SECTION B-B
DRILL 7/32 DIA. HOLE (TYP. 8 PLACES)
MS20257C4-1000 CONTINUOUS HINGE
HINGE

AM.634

Figure 9-38.—Cartridge block.

Rotate the top latch mechanism handwheel counterclockwise and remove it. Insure that the locking plunger is flush with the housing and the indicating dowel is flush with the locking plunger as shown in figure 9-16. If the locking plunger and indicating dowel are not flush with the housing the seat is not properly installed.

The seat-to-aircraft connections consist of connecting the drogue gun and time release trip rods to the ejection gun crossbeam, connecting the electrical connector for the seat actuator, connecting the leg restraint to the deck fittings, and connecting of the oxygen, communications, anti-g, and vent lines to the aircraft connectors. The disconnect lanyard from the personnel services disconnect block is connected to the cockpit deck fitting.

ARMING THE ROCKET MOTOR INITIATOR.—Remove the guard from the initiator assembly, then remove the pip-pin and disconnect the gas line from the initiator connector. (See fig. 9-36.) Connect the firing lanyard to the drogue gun trip rod and install the safety pin.

With the sear inserted into the firing mechanism, insure that the firing pin does not protrude. Install safety wire through the sear ground lock safety pin hole. Install the correct cartridge into the initiator body, insert the firing mechanism and torque as specified in the applicable Maintenance Instructions Manual.

Remove the safety wire from the sear hole and install a ground lock pin. Quality Assurance AME will install the lockwire and affix a lead seal to the firing mechanism.

With the safety pin installed in the sear, press in on the sear and engage the firing link. Reconnect the gas line and install the pip-pin and guard.

ARMING THE DROGUE GUN.—Check the connection of the drogue gun trip rod to the crossbeam of the ejection gun. Install the correct cartridge in the drogue gun barrel. Insure that the firing pin in the drogue gun body is not protruding and that the sear and ground lock pin are installed.

With the drogue cartridge inserted in the body of the drogue gun, insert the barrel and tighten to the torque specified in the applicable Maintenance Instructions Manual. A Quality Assurance Representative will lockwire the barrel-to-body connection and affix a lead seal.

Complete the arming of the drogue gun by connecting the controller drogue withdrawal line to the drogue gun projectile. Refer to figure 9-22.

PRIMARY CATAPULT CARTRIDGE INSTALLATION.—Remove the primary firing mechanism and insure that the sear is installed and the firing pin does not protrude from the base. Install safety wire in the ground lock pin hole of the sear. Install the cartridge into the breech using a new water seal (See fig. 9-24.) Install the inner tube retaining ring around the firing mechanism and install the firing mechanism into the breech. Torque as specified in the applicable Maintenance Instructions Manual. Allow the Quality Assurance Representative to lockwire the installation and affix the lead seal.

Remove the safety wire from the sear and install a ground lock pin in its place. With the safety pin installed, press forward on the sear and engage the firing linkage.

Check that there is no safety pin in the power inertia reel and the guillotine sears. As the last step of the seat preflight before entering the cockpit the pilot or a properly qualified plane captain removes the six ground lock pins and flags and stows them in their container.

Upon return of the aircraft from a flight the ground lock pins and flaps must be installed immediately to prevent inadvertent ejection of the seat and canopy.

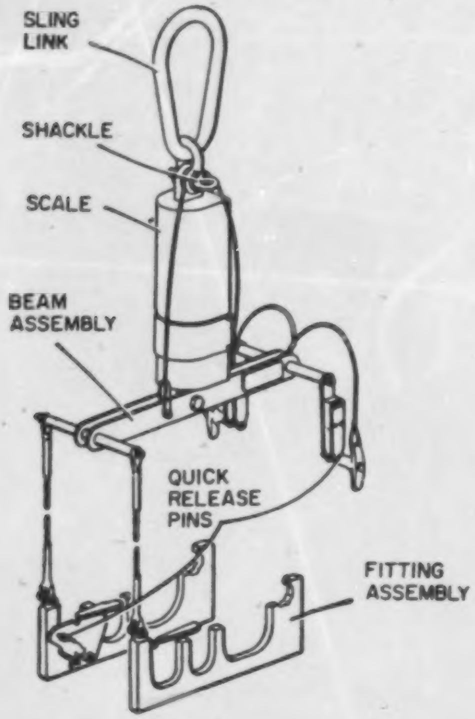
Seat dearming and removal is essentially the reversal of the installation and arming procedures. All maintenance must be performed as specified in the applicable Maintenance Instructions Manual.

Special Tools and Equipment

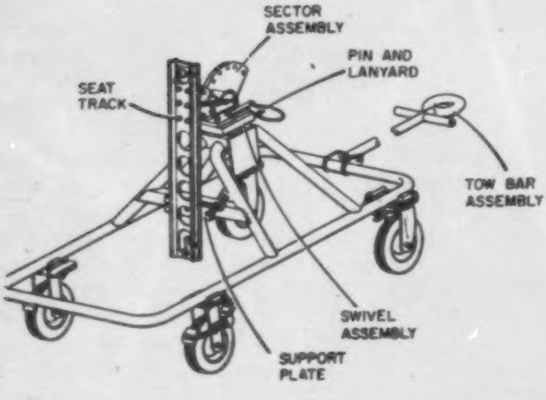
Each ejection seat model requires certain special tools and equipment for safe maintenance and handling. Of course, some of these special tools have the same name, but their use cannot be interchanged. For instance, hoisting slings—there are Martin-Baker hoisting slings, ESCAPAC hoisting slings, and LS-1 hoisting slings, and each one is suitable for the one seat. Figure 9-39 illustrates the sling used with the Martin-Baker ejection seat.

When the ejection seat is removed from the aircraft, a dolly or cradle is used to move or merely support the seat. Figure 9-40 illustrates the ejection seat maintenance cradle assembly designed for the Martin-Baker seat.

The seat track is the same as the track on the ejection gun. The seat is made fast to the track and is adjustable to several positions for ease of maintenance.



AM.188
Figure 9-39.—Ejection seat hoisting sling assembly.



AM.189
Figure 9-40.—Ejection seat cradle assembly.

Adjustment is accomplished by rotating the track and arm assembly around the sector assembly and pinning it in the desired position on the sector by use of a quick-release pin.

ROCKET ASSISTED EJECTION CATAPULT ESCAPAC 1-C3

Another of the latest types of ejection systems used in naval aircraft is the rocket assisted ESCAPAC system. The ESCAPAC like the Martin-Baker has several variations between seat models. Seat modifications have been incorporated to provide the occupant with an improved escape and recovery system by incorporating a seat stabilization and snubbing device which assures directional stability during ejection and positive seat-man separation. The stabilization and snubbing device is referred to as the Directional Automatic Realignment of Trajectory (DART) stabilization and snubber system.

DESCRIPTION

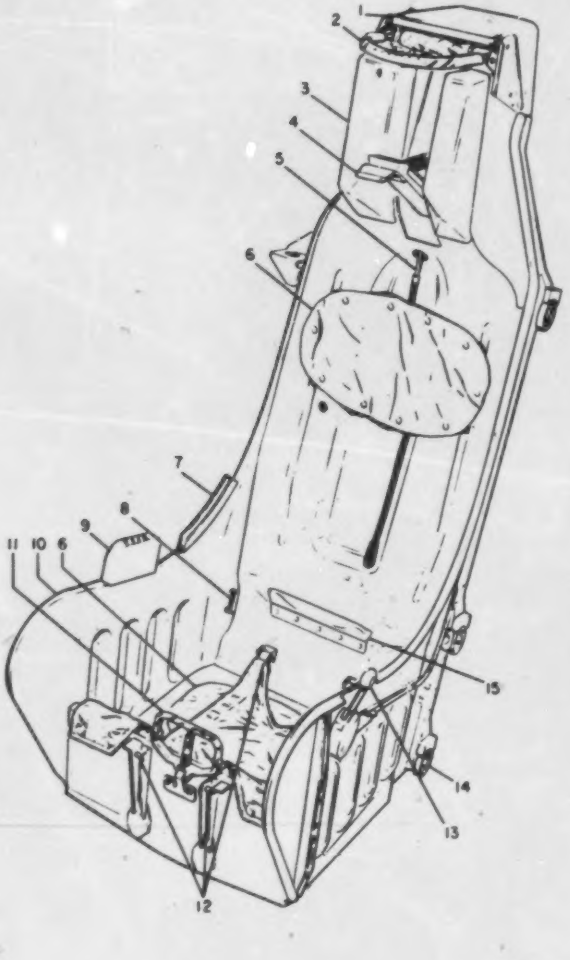
Following initiation of the ejection, the system is fully automatic through the ejection sequence of rocket thrust, rocket burnout, seat-occupant separation, parachute pack opening, deployment, and full canopy inflation.

The ESCAPAC 1-C3 ejection seat utilized with the A-4F aircraft and discussed in this chapter provides escape capability from ground level at 0 knots airspeed to all altitudes and airspeeds within the operational limits of the aircraft.

Figures 9-41 and 9-42 show the front and back views of the ESCAPAC 1-C3 seat and its various components.

The seat assembly, constructed almost entirely of aluminum, provides minimum weight to prevent loss of energy. As in the Martin-Baker seat, two ejection handles are incorporated into the seat structure—one above the occupant's head, connected to a face curtain to cover the face for added protection; and another on the front of the seat bucket to be used in emergency conditions, in the event excessive g force, wounds, or shock prevent the use of the face curtain handle. Both handles initiate ejection without any extra apparatus.

An ejection control safety handle is contained between the two headrest pads. When the safety handle is in the full down position, both ejection control handles are in a safe condition.



AM.156

Figure 9-41.—Rocket catapult ejection seat (A-4F—ESCAPAC 1-C3).

Nomenclature for figure 9-41.

1. Face curtain cover.
2. Face curtain ejection control handle.
3. Dual headrests.
4. Ejection control safety lever and handle.
5. Shoulder harness disconnect cable.
6. Separation bladder (2 places).
7. Parachute arming lanyard channel.
8. Harness release fittings.
9. Harness release handle.
10. Leg protection side support.
11. Secondary ejection control handle.
12. Survival kit separation system.
13. Inertia reel manual control assembly.
14. Roller fitting (6 places).
15. Rubber coated parachute support shelf.

A firing control disconnect assembly is located aft of the face curtain control handle and consists of a firing control disconnect assembly, a safety lockpin, and a cable assembly. The face curtain control handle cables and the secondary control handle cable are attached to the disconnect assembly and actuate the assembly when pulled. The disconnect assembly provides necessary mechanical action to actuate the inertia reel assembly and the rocket catapult initiators.

The firing control disconnect assembly controls both the firing of the rocket catapult and the release of the face curtain handle cables and/or the secondary ejection control handle cables from the seat during ejection.

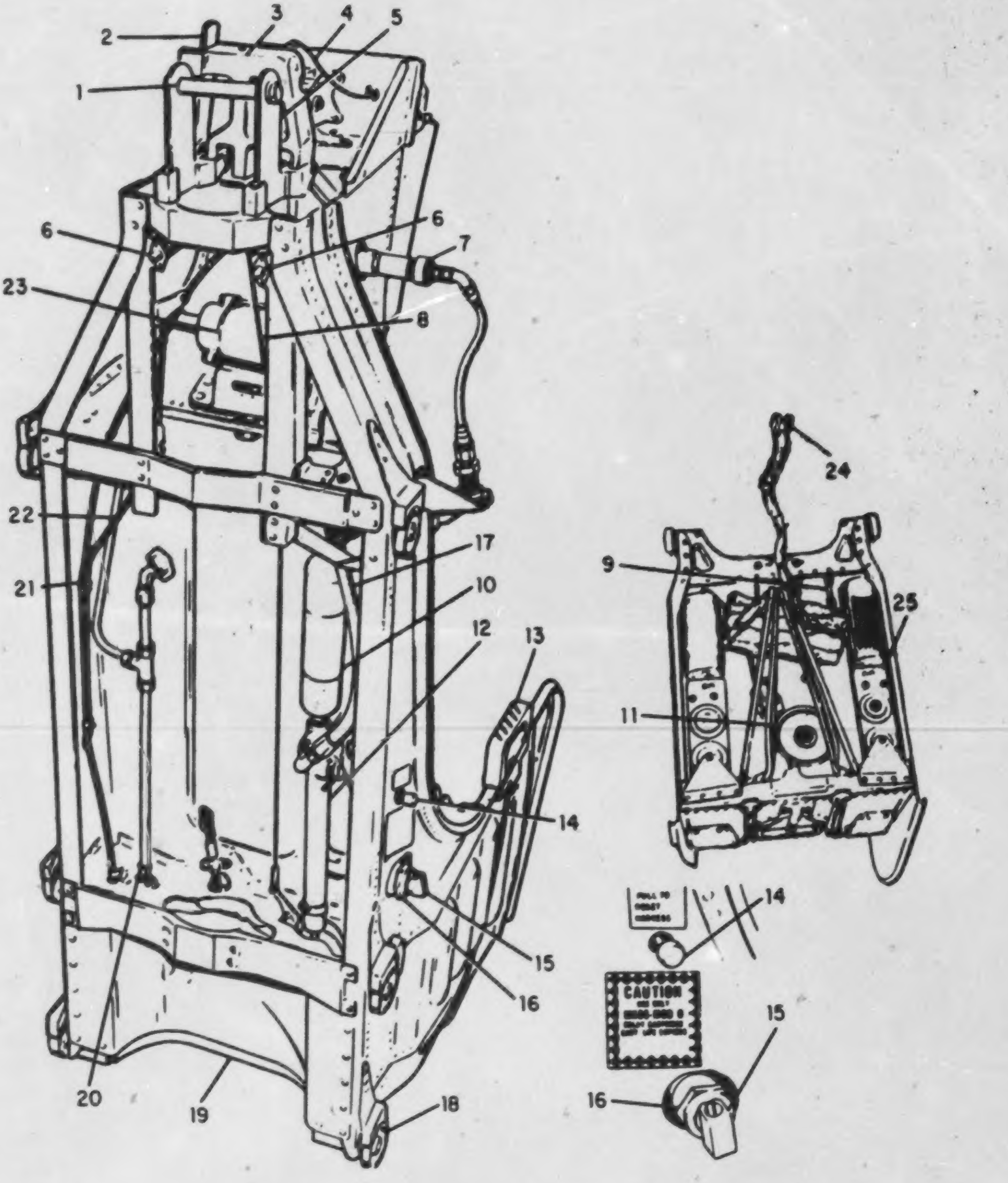
Figure 9-43 shows the various seat cable assemblies.

The seat stabilization system counteracts the adverse effects of aerodynamics and variation of the center of gravity of the seat-man combination during the rocket burning stage. The stabilization system is installed on the underside of the seat bucket and consists of two brake units, a deployable bridle arrangement, and four nylon drag lines. Portions of the system lines are stowed in two fabric pouches mounted on the seat.

The ESCAPAC seat also features a separation system to release the occupant upon ejection from the seat structure. A harness release bellcrank assembly located behind the seat releases all connections of seat and occupant after ejection from the cockpit. An inflation bladder system employs two nylon bladders, one on the seat bottom and one at the seat back, which inflate with pressurized gases to forcibly separate the seat from the occupant after harness release occurs.

The separation system also releases the ejection control handle (whichever might be used), and allows the occupant to maintain a grip on it during his descent and after seat separation. This release of either ejection control handle is governed by the firing control disconnect assembly, which operates in unison with the bellcrank harness release system.

A semirigid parachute pack is incorporated into the ESCAPAC seat and provides lower back support. The parachute used with the ESCAPAC 1-C3 ejection seat discussed in this section has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CAUTION
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AM.1198

Figure 9-42.—Ejection seat assembly (ESCAPAC 1-C3—rear view).

Nomenclature for figure 9-42.

1. Rocket catapult-seat attachment bolt.
2. Catapult firing control.
3. Firing controls disconnect assembly.
4. Face curtain left-hand control cable.
5. Catapult support bracket assembly.
6. Catapult initiator firing rods.
7. Power inertia reel cartridge.
8. Firing control disconnect cable.
9. Separation bladder tubing.
10. Nitrogen bottle.
11. Secondary ejection control disconnect pulley assembly.
12. Harness release actuator.
13. Harness release handle.
14. Harness release actuator manual detent pin.
15. Harness release actuator firing pin shear.
16. Harness release actuator firing pin assembly.
17. Separation bladder flex hose assembly.
18. Roller (6 places).
19. Rocket catapult blast shield.
20. Separation bladder tubing (seat back).
21. Secondary ejection control cable.
22. Inertia reel manual control cable.
23. Shoulder harness inertia reel assembly.
24. Floor attaching fitting.
25. Seat stabilization system.

an external pilot chute and a ballistics skirt spreader which provide positive canopy deployment and inflation.

An automatic release actuator is employed on the parachute to provide automatic parachute opening below 14,000 (±500) feet and to prevent automatic opening above this preset altitude. When the seat occupant ejects above 14,000 (±500) feet, the parachute will delay opening until he has descended to 14,000 (±500) feet (plus a 3/4-second time delay). When ejection occurs below this altitude, a delay mechanism prevents parachute opening until after seat-man separation.

NOTE: The NB-11 parachute ballistics skirt spreader should be considered dangerous like other pyrotechnic devices. If, during parachute removal or installation, for any reason, the parachute pack is accidentally opened, the AME should immediately contact an aircrew survival equipmentman (PR) so that the ballistics spreader can be safetied. Any attempt to pick up the parachute, shroud lines, and pack to transport it to the survival equipment work center could result in firing of the ballistics cartridge device. Since the type of parachute used in various aircraft is subjected to rapid change, always check the current MIM for the aircraft being worked on for specific parachute removal and installation procedures and handling precautions.

The ESCAPAC seat may be adjusted to various positions to provide for pilot comfort by operating the ejection seat actuator assembly.

NOTE: Operation of the ESCAPAC seat is closely interrelated with release of the cockpit canopy.

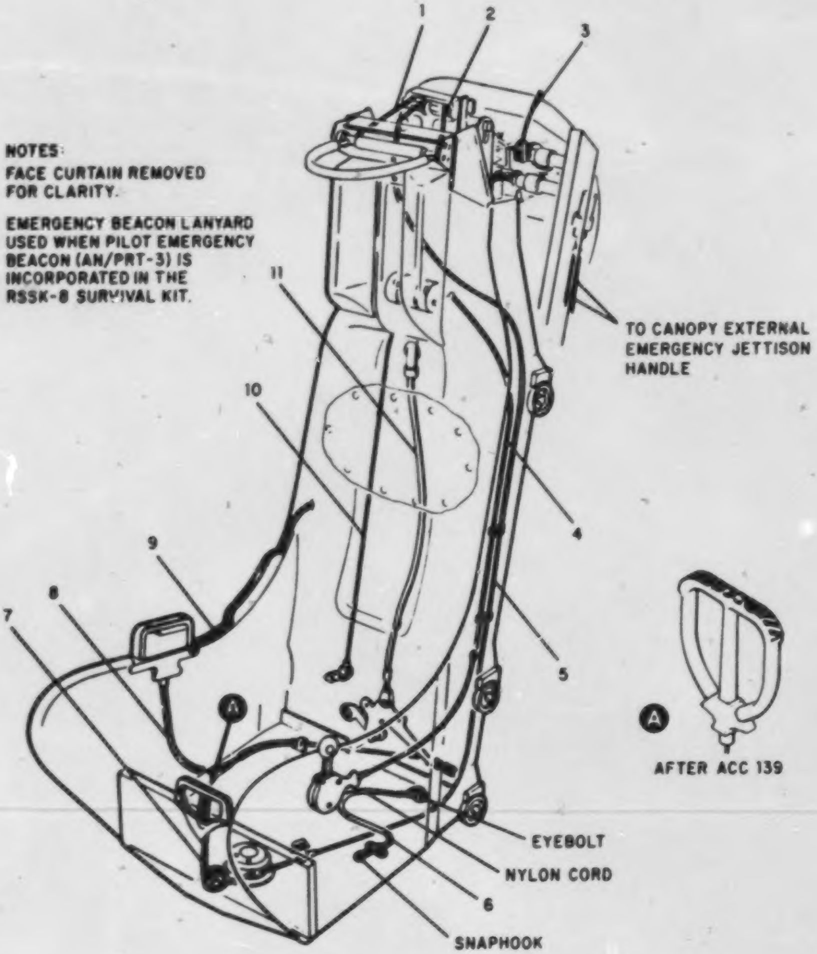
WARNING: High explosives contained within the ESCAPAC rocket can cause serious injury or death to anyone unfamiliar with its operation. Carelessness on the part of qualified personnel and departure from the Maintenance Instructions Manual procedures is equally dangerous. All repairs performed on the seat must be accomplished by highly qualified personnel in strict accordance with the procedures in the applicable Maintenance Instructions Manuals.

EJECTION SEQUENCE

Under conditions where ejection must be made immediately, the pilot grasps the face curtain handle (or secondary firing control handle) and pulls steadily. (See fig. 9-44.) As either handle is actuated, the canopy jettison initiators and inertia reel booster initiators are activated, the inertia reels retract the shoulder harness and the canopy jettisons.

As the canopy is jettisoned, the canopy seat interlock lanyard actuates two initiators. Gases generated by the initiator cartridges actuate the canopy interlock assembly. Gas pressure against the rod end of the actuator releases the canopy interlock stop, allowing additional ejection handle travel.

Continued pull on the face curtain control handle or the secondary handle moves the firing control disconnect assembly counterclockwise. The catapult initiator firing rod assembly moves against the initiator cranks, and the rocket catapult initiators are activated. Gases generated by the firing of the initiator cartridges fire the rocket catapult and move the seat upwards.



NOTES:
FACE CURTAIN REMOVED FOR CLARITY.

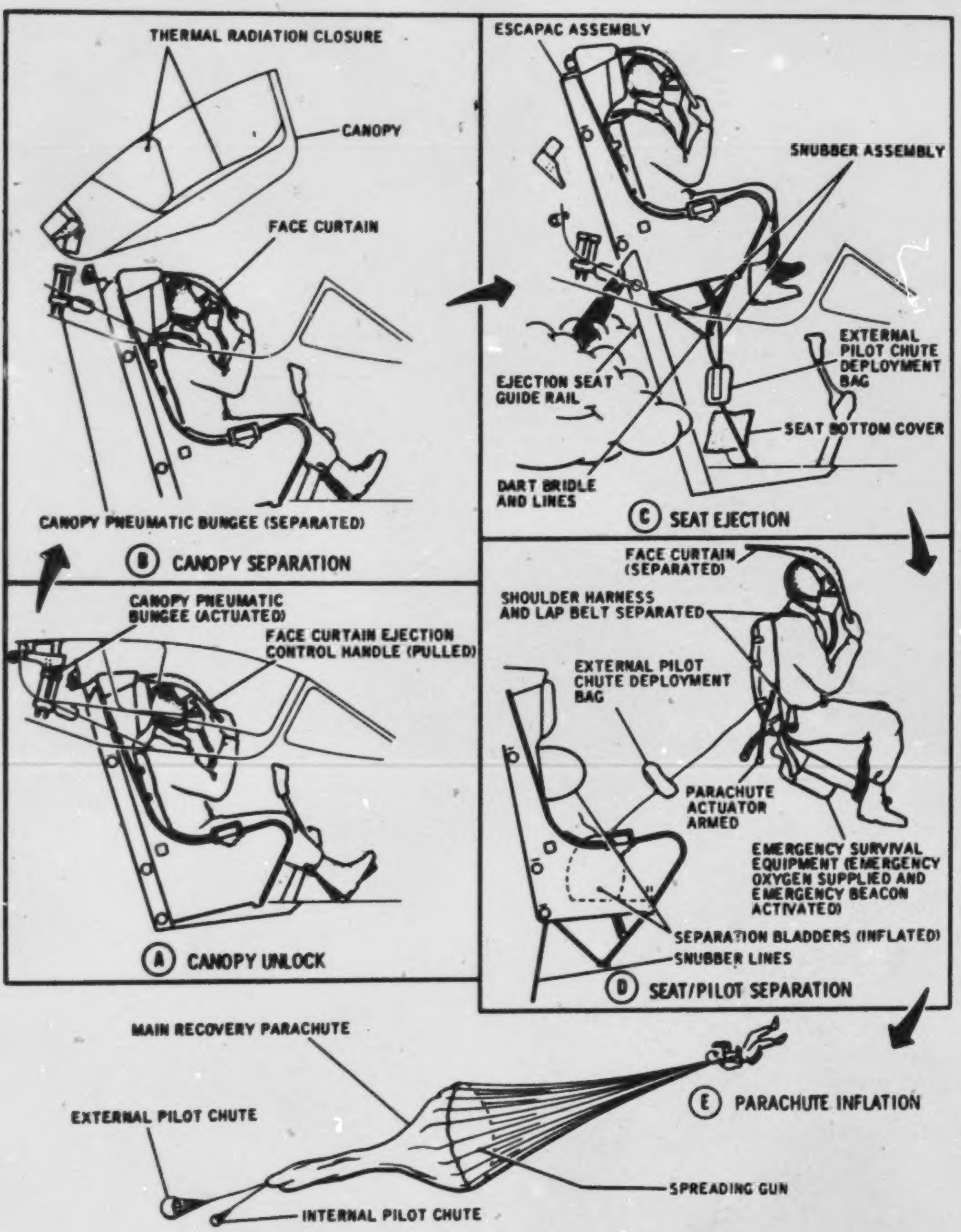
EMERGENCY BEACON LANYARD USED WHEN PILOT EMERGENCY BEACON (AN/PRT-3) IS INCORPORATED IN THE RSSK-8 SURVIVAL KIT.

1
2
3
11
TO CANOPY EXTERNAL EMERGENCY JETTISON HANDLE
10
4
9
8
7
A
5
A
AFTER ACC 139
EYEBOLT
NYLON CORD
6
SNAPHOOK

AM.1199

1. Face curtain RH control cable.
2. Face curtain LH control cable.
3. Canopy interlock release cable assembly.
4. Inertia reel manual control cable.
5. Secondary ejection control cable.
6. Pilot emergency beacon lanyard.
7. Secondary ejection control cable (handle assembly).
8. Harness release handle cable assembly.
9. Parachute arming lanyard (cable).
10. Firing control disconnect cable assembly.
11. Shoulder harness disconnect cable assembly.

Figure 9-43.—Ejection seat cable assemblies.


THERMAL RADIATION CLOSURE
CANOPY
FACE CURTAIN
CANOPY PNEUMATIC BUNGEE (SEPARATED)
B CANOPY SEPARATION
ESCAPAC ASSEMBLY
SNUBBER ASSEMBLY
EXTERNAL PILOT CHUTE DEPLOYMENT BAG
EJECTION SEAT GUIDE RAIL
SEAT BOTTOM COVER
DART BRIDLE AND LINES
C SEAT EJECTION
CANOPY PNEUMATIC BUNGEE (ACTUATED)
FACE CURTAIN EJECTION CONTROL HANDLE (PULLED)
A CANOPY UNLOCK
FACE CURTAIN (SEPARATED)
SHOULDER HARNESS AND LAP BELT SEPARATED
EXTERNAL PILOT CHUTE DEPLOYMENT BAG
PARACHUTE ACTUATOR ARMED
EMERGENCY SURVIVAL EQUIPMENT (EMERGENCY OXYGEN SUPPLIED AND EMERGENCY BEACON ACTIVATED)
SEPARATION BLADDERS (INFLATED)
SNUBBER LINES
D SEAT/PILOT SEPARATION
MAIN RECOVERY PARACHUTE
EXTERNAL PILOT CHUTE
E PARACHUTE INFLATION
SPREADING GUN
INTERNAL PILOT CHUTE

AM.1200

Figure 9-44.—Ejection seat sequence (zero-zero).

The rocket, building up thrust, begins to raise the seat out of the cockpit area. (See fig. 9-44, view C.) Anti-g and oxygen hoses break away from the cockpit anti-g and oxygen control panel, and the pilot begins to breathe emergency oxygen from the cylinder contained in the survival kit. The force of acceleration draws the pilot's legs down and back against the front panel of the seat assembly.

Further travel of the seat up the guide rails causes the harness release actuator sear to hit the striker plate, removing the sear and firing a 1-second time delay cartridge. As the seat nears the top of the guide rails, the rocket sustainer portion of the rocket catapult is ignited. The 2,000 pounds (approximately) per second impulse rocket catapult accelerates the seat to a safe descent level.

As the seat travels upward after leaving the rails, the seat stabilization and snubbing system contained in the seat and connected to the cockpit floor is deployed, imparting corrective rotational forces to assure proper orientation of seat and pilot, at rocket burnout, for a successful ejection.

Explosion of the delay cartridge causes a piston within the harness release actuator to rise and break the nitrogen bottle diaphragm. In its travel upward, the piston also actuates a bellcrank attached to a clevis at the lower end of the piston. The bellcrank, rotated counterclockwise, releases the left- and right-hand lap belt pins and the shoulder harness cable assembly. The pilot is no longer secured to the seat.

When the bottle is ruptured by the piston in the harness release actuator, compressed, dry nitrogen stored within the nitrogen bottle travels through hose assemblies into the two inflation bladders—one under the seat assembly, and one behind the parachute kit. As the bladders inflate, the pilot (with survival gear attached) is separated from the seat assembly. The firing control disconnect releases the cables attached to the face curtain and/or secondary ejection control handle, allowing the pilot after seat separation to maintain a grip on whichever handle is used for seat ejection.

A parachute actuator arming lanyard is actuated as the seat/man separation occurs, arming the automatic parachute actuator. An external pilot chute static line routed beside the parachute actuator arming cable is spot tacked (tied) to various points of the arming cable. A ring on the end of the static line is fitted over the swaged ball end before the ball end is fitted into the harness release handle.

Simultaneous with seat/man separation and arming of the automatic parachute actuator, tension on the external pilot chute static line causes the external pilot chute to deploy, insuring rapid deployment of the pilots main chute. (See fig. 9-44, view D.) If the aircraft speed is above 120 knots, the external pilot chute connection to the main chute is disconnected by a separation link and the internal pilot chute assists in main chute deployment.

The parachute is set to open within 3/4 seconds, if the ejection was initiated below the preset altitude, or after freefall to the preset altitude of 14,000 (± 500) feet (plus a 3/4-second delay).

If the ejection is over water, the pilot must pull the seat pack release handle to deploy the life raft. The life raft will automatically inflate and suspend from a 20-foot lanyard. Deploying the RSSK-8 seat pack is not recommended for ejections over wooded areas. The survival kit contains the emergency oxygen supply, the life raft, and survival supplies for use until rescued.

DESCRIPTION AND OPERATION OF COMPONENTS

The various components of the ESCAPAC system may be divided into the following groups—ejection equipment, separation equipment, survival equipment, and safety equipment.

Ejection Equipment

Ejection equipment consists of all components used or related to the ejection of the seat and occupant from the cockpit. Components of ejection equipment include the following:

Seat assembly.
Cable assemblies
Mk 13 Mod 0, 1, or 2 rocket catapult.
Firing control disconnect assembly.
Face curtain ejection control handle assembly.
Secondary ejection control handle assembly
Seat stabilization system.

Normal ejection occurs as the overhead face curtain ejection handle is pulled forward. If emergency conditions prevent reaching upward to the face curtain ejection handle assembly, the secondary ejection handle located on the front seat beam of the seat assembly is used. In pulling either handle, the firing control disconnect assembly is actuated.

The face curtain and secondary ejection control handle cable assemblies are connected to the firing control disconnect assembly. A harness release bellcrank assembly, located on the lower aft portion of the seat, releases all connections between seat and occupant after ejection from the cockpit.

SEAT ASSEMBLY.—The seat assembly consists of a lightweight, aluminum structure offering maximum comfort and protection. A dual strap power inertia reel, located below the ejection control safety handle, attaches to the survival equipment shoulder harness. The inertia reel automatically positions the pilot in the correct attitude for the ejection sequence. The inertia reel is governed by a manual control lever located on the left-hand side of the seat bucket.

A manual harness release handle is located on the right-hand side of the seat bucket to provide emergency release and normal removal and installation of the survival equipment. A harness release actuator is installed at the right-hand back of the seat structure. The actuator contains a nitrogen storage bottle at its top and a piston, connected by a clevis to the bellcrank, at its base.

A sear, protruding from the right-hand side of the seat structure, actuates the firing pin assembly within the actuator upon seat ejection. A blast shield, held in position with 12 screws and washers, protects the bellcrank area from rocket blast upon detonation.

The ejection seat assembly is installed in the aircraft by attaching the upper bracket of the seat structure to the rocket catapult attaching eye. The rocket catapult is attached at the base of the launcher tube to the seat actuator assembly which is mounted on support brackets.

Two guide rails, installed on the canted bulkhead, engage three rollers mounted on each side of the ejection seat, permitting proper vertical direction of the seat out of the cockpit, while also acting as a guide for normal raising or lowering of the seat by the actuator assembly.

CABLE ASSEMBLIES.—Various cables are integrated into the rocket catapult seat structure to provide effective use of the seat components. (See fig. 9-43.)

1. The firing control disconnect cable assembly is attached to the harness release bellcrank. Downward movement of the cable allows separation of the control handles from the ejection seat.
2. The secondary ejection control handles cable assembly leads from the front face of the seat bucket and attaches to the secondary firing control pulley under the seat structure to provide a secondary ejection handle for use in emergency conditions.
3. The harness release handle cable assembly leads from a holder on the right-hand side of the seat assembly and connects the harness release handle to the outer arm of the bellcrank assembly located under the seat structure.
4. The parachute actuator arming cable and housing is fitted into a forked pin on the harness release handle and travels upward in a metal channel on the right-hand side of the seat and into the parachute assembly where it is hooked to the automatic parachute actuator. Pulling of the cable from the parachute arms the automatic actuator.
5. The shoulder harness disconnect cable assembly leads from the bellcrank to the shoulder harness disconnect housing at the base of the dual strap inertia reel and provides an anchor point for the extension of the dual straps of the inertia reel.
6. The inertia reel control cable assembly leads from the inertia reel manual control lever on the left-hand side of the seat structure to the dual strap inertia reel at the base of the headrest assembly. Actuation of the control cable assembly permits manual selection of a locked or unlocked condition of the inertia reel. Cycling of the manual control lever from UNLOCKED to LOCKED and back to UNLOCKED releases an intertially induced locked condition of the reel.

ROCKET CATAPULT MK 13 MOD 0, MK 13 MOD 1, or MK 13 MOD 2.—The Mk 13 Mod 0 rocked catapult on aircraft not reworked per ACC 103 (Int) and the Mk 13 Mod 1 rocket catapult on aircraft reworked per ACC 103 (Int) or Mk 13 Mod 2 are self-contained, gas-initiated rockets designed to eject the pilot and seat from the aircraft.

When a control handle is pulled, an initiator is activated. Pressurized gases created by the initiator cartridge retract the shoulder harness and jettison the canopy. A canopy-seat interlock lanyard assembly is removed when the canopy is jettisoned.

Continued pull on the control handle fires two initiators, introducing pressurized gases into the catapult firing system which initiate the firing pin in the lower part of the catapult tube. (See fig. 9-45.)

The gas pressure shears the pin which holds the catapult firing pin in place. The firing pin travels approximately 3/4-inch developing enough energy to fire the percussion primer in the cartridge assembly. Pressure created by the cartridge firing causes the unlock sleeve to move downward compressing the unlock spring and releasing the lower tangs of the lock and pad assembly. With the lower tangs released, movement of the rocket motor assembly begins and the seat goes up the guide rails.

As gas from the main cartridge charge expands and drives the assembly up the outer housing, the nozzle is kept sealed by the motor-lock disc. Near the end of the catapult stroke, the motion of the unlocked sleeve is stopped by interference with the front body housing.

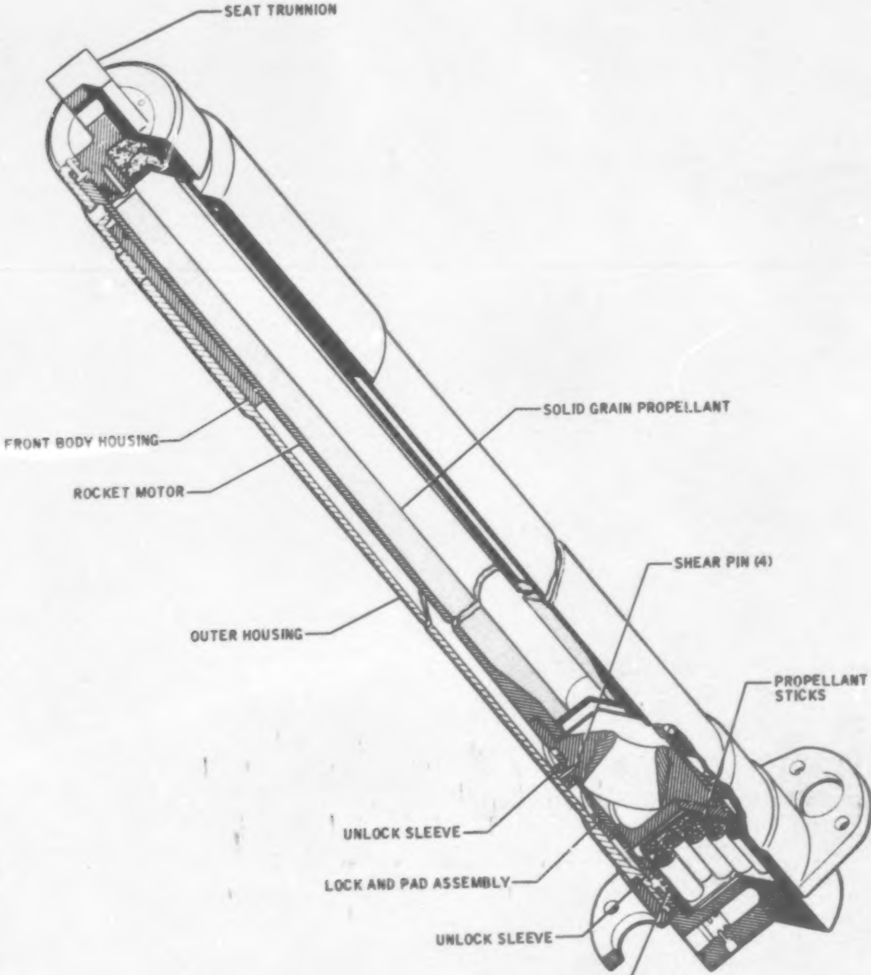

SEAT TRUNNION
SOLID GRAIN PROPELLANT
FRONT BODY HOUSING
ROCKET MOTOR
SHEAR PIN (4)
OUTER HOUSING
PROPELLANT STICKS
UNLOCK SLEEVE
LOCK AND PAD ASSEMBLY
UNLOCK SLEEVE
UNLOCK SPRING
AM. 163

Figure 9-45.—Rocket Catapult Mk 13 Mod 0, 1, or 2.

When the rocket motor has traveled approximately another 0.8-inch, the shoulder on the lock and pad assembly strikes the immobilized unlock sleeve and stops. This action releases the upper tangs of the lock and pad assembly and unseals the rocket motor nozzle. Hot gases pass into the rocket motor assembly through the nozzle and ignite the rocket motor ignition material which in turn ignites the solid-propellant grain.

The rocket motor then leaves the outer housing and provides the thrust required to carry the seat-man mass to a sufficient height for safe descent. Figure 9-46 illustrates the ignition sequence of the Mk 13 rocket catapult.

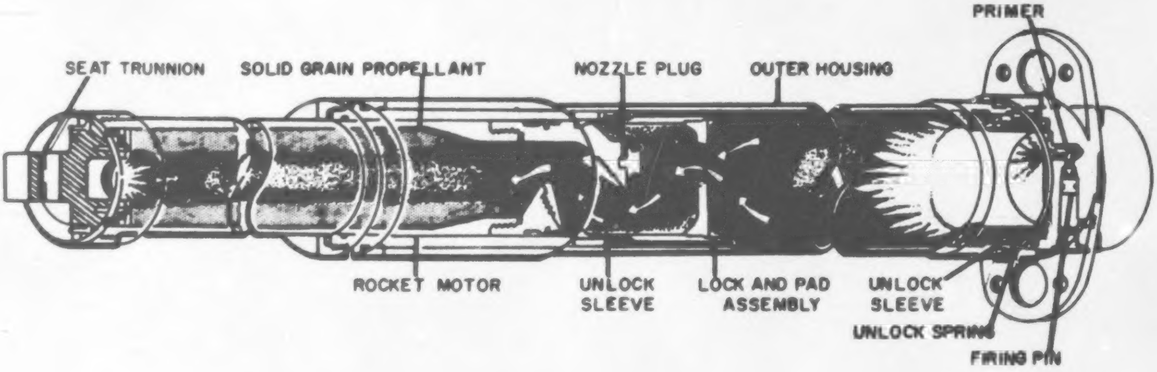
FIRING CONTROL DISCONNECT ASSEMBLY.—The firing control disconnect assembly (fig. 9-47) is located aft of the face curtain control handle and consists of a firing control disconnect assembly, a safety lockpin, and a cable assembly. The face curtain control handle cable and the secondary ejection control handle cable are attached to the disconnect assembly and actuate the assembly when pulled. The disconnect assembly provides necessary mechanical action to actuate the inertia reel assembly and the rocket catapult initiators.

The firing control disconnect assembly controls both the firing of the rocket catapult and the release of the face curtain handle cables and/or the secondary ejection control handle cables from the seat during ejection. As the canopy clears the ejection path, the seat-canopy interlock is removed, allowing the firing controls disconnect assembly to pivot forward and actuate the initiator firing rods. As the firing rods move aft, the rods actuate the initiators, the power inertia reel retracts to position the pilot properly for the ejection sequence, and the catapult fires.

As the seat moves up the guide rails, the harness release actuator is armed by the striker plate. After a 1-second delay, the harness release actuator fires, rotates the bellcrank attached to the harness release actuator piston, and releases the lap belt and shoulder harness pins. A clevis on the piston contacts the firing control disconnect arm.

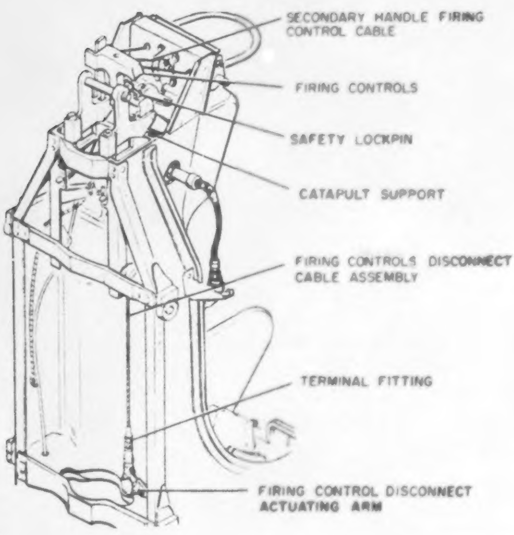
The actuating arm downward movement pulls the firing control disconnect cable and withdraws the spring-loaded firing control disconnect pin on the upper end of the disconnect cable. The disconnect pin and spring are located within the firing control disconnect housing. Withdrawal of the disconnect pin in the housing releases the firing control release fitting, and both control handles disconnect. Separation of the cables on the face curtain or the secondary ejection control handle completely disconnects the pilot from the seat while maintaining a grip on either ejection control handle.

The firing control safety lockpin is channeled into the ground safety socket. When the ejection control safety handle is pulled down, the safety lockpin rests against the safety handle lockpin, preventing movement of the firing control disconnect assembly.



AM. 667

Figure 9-46.—Rocket Catapult Mk 13 Mod 0, 1, or 2—Ignition sequence.


SECONDARY HANDLE FIRING CONTROL CABLE
FIRING CONTROLS
SAFETY LOCKPIN
CATAPULT SUPPORT
FIRING CONTROLS DISCONNECT CABLE ASSEMBLY
TERMINAL FITTING
FIRING CONTROL DISCONNECT ACTUATING ARM

AM. 164

Figure 9-47.—Firing control disconnect assembly.

The firing control release fitting provides for detent and release of the control handle cables. The fitting is held in the detent position by the springloaded firing control disconnect pin. When the pin is withdrawn from the fitting by the downward movement of the firing control cable assembly, the fitting is released, allowing separation of the control handles.

FACE CURTAIN EJECTION CONTROL HANDLE ASSEMBLY—The face curtain ejection control handle assembly (fig. 9-48) consists of a molded-rubber handle, guide tube (with encased spring), a nylon face curtain, and two cables. The control handle assembly is connected to the firing control disconnet assembly by two cables.

When the face curtain ejection control handle is pulled out and down with sufficient force to overcome the tension supplied by the spring, the detent bars are released from the sockets and the seat ejection sequence is initiated.

The handle has black and yellow stripes and is identified PULL TO EJECT SEAT. Handle construction is flexible enough to permit removal of the detent bars from the face curtain guide tube, allowing removal and installation of the face curtain.

The face curtain consists of a rectangular strip of nylon. The forward portion of the face curtain is fitted around the guide tube to permit forward movement when the ejection control handle assembly is pulled forward. Two cables extending to the firing control disconnect assembly are attached with swaged fittings. The cables, which lead to the spring tensioned guide tube, are attached to the face curtain. When using the face curtain ejection control handle assembly the two cables connected to the handle are released from detents in the ejection control pulleys to separate the handle, gripped by the pilot, and the cables from the ejected seat.

SECONDARY EJECTION CONTROL HANDLE.—The secondary ejection control handle (fig. 9-49), located on the front face of the seat bucket, is used only in emergency circumstances for seat ejection when the face curtain handle malfunctions or is not available to the pilot, either because of excessive g force, shock, or injury.

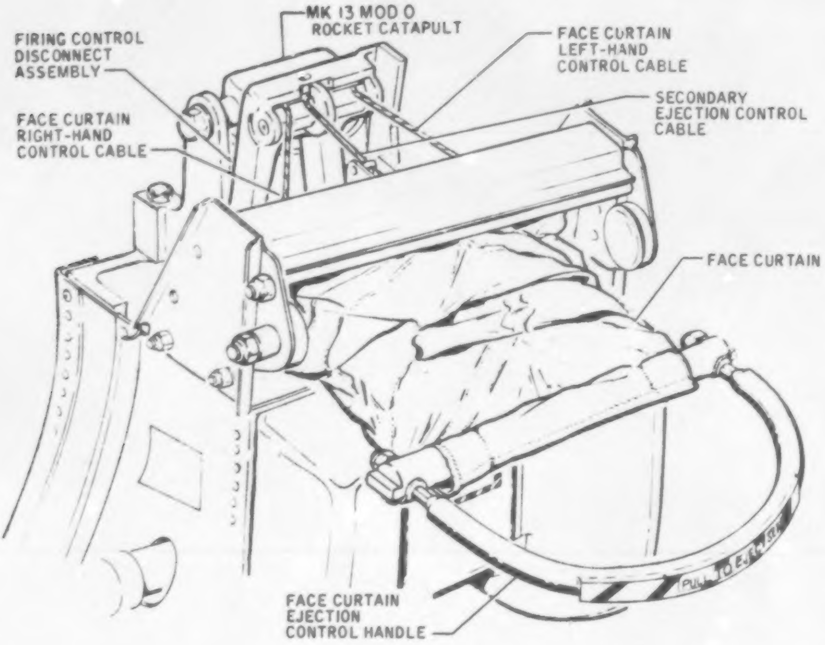
The secondary control handle is a rectangular, yellow and black striped handle, designated on the upper surface PULL TO EJECT. The handle is hinged on each side of the grip area allowing it to fold aft when the control stick is pulled back far enough to contact the handle and folds forward during pilot-seat separation. A tension spring returns and maintains the handle in a vertical position.

NOTE: The ejection handle on seats reworked per AirCrew Change 139 consists of a cable and molded rubber handle assembly and is not hinged.

The lower portion of the assembly connects to the secondary ejection control pulley mechanism on the lower surface of the ejection seat. As the handle is pulled upward, the cable from the handle rotates the pulley mechanism beneath the seat which, in turn, actuates the disconnect assembly that jettisons the canopy and fires the rocket catapult.

After pilot and seat separation, the secondary ejection control handle is disconnected from the seat structure, allowing the pilot to maintain a grip on the handle during descent.

INTERLOCK CAM AND PIN ASSEMBLY.—The interlock cam and pin assembly is located on the left side of the canted bulkhead. Its purpose is to prevent the seat ejection prior to canopy jettison and accidental ignition of the catapult rocket during maintenance operations. Figure 9-50 shows the interclock cam and pin assembly with the safety pin block assembly installed. This represents one of the three safety



AM.165

Figure 9-48.—Face curtain control handle.

devices used to safety the seat when the aircraft is on the ground.

The spring-tensioned pin is attached to a cable and a retainer. The aft portion of the pin protrudes through a hole in the interlock support and is held in place by the interlock cam. The firing control disconnect assembly is thus held in position and eliminates the possibility of firing the rocket catapult prior to canopy jettison as the disconnect must be pulled forward to fire.

During the ejection cycle the canopy pulls the interlock pin assembly as the canopy clears the ejection path. The interlock, free of the pin, allows further pull on the ejection control handle.

SEAT STABILIZATION SYSTEM.—The seat stabilization system prevents the seat from rotating forward or aft during the rocket burning stage, and provides consistent and predictable trajectory paths.

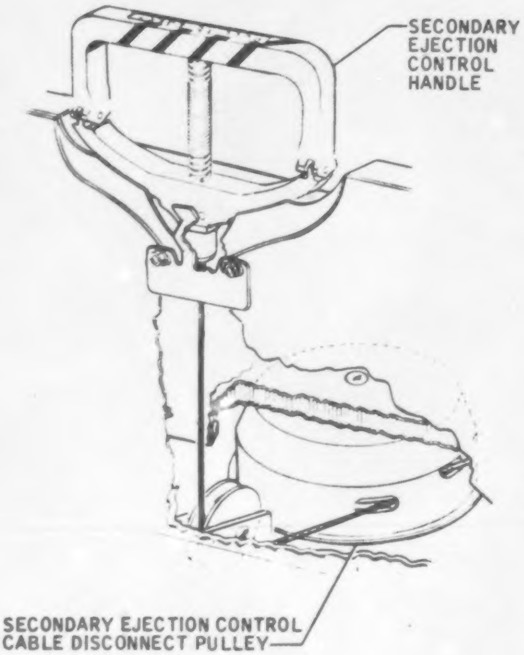
The stabilization system is installed on the underside of the seat bucket and consists of two brake units, a deployable bridle arrangement, and four nylon drag lines. Portions of the system lines are stowed in two fabric pouches mounted on the seat. The lines are routed through the brake units and through the eye of the bridle. At the eye, the remaining lengths of the system lines are gathered and covered with a flame retarded sleeve. The covered section of the line is stowed in a deployable pouch, and the end is attached to the aircraft floor structure. (See fig. 9-42.)

As the seat ejects, the slack line stowed in the deployable pouch pays out and the bridle drops into position. At a preprogramed distance, the system lines are pulled through the brake units, developing a preprogramed force in the lines and, consequently, a moment of force around the system center of gravity which counteracts any adverse rotation of the seat.

Separation Equipment

The separation equipment includes all components which restrain, release, and forcibly separate seat from pilot after seat ejection. Separation equipment is shown in figure 9-51.

Upon seat ejection, as the seat and occupant accelerate upward and out of the cockpit, a striker plate attached to the right-hand guide


SECONDARY EJECTION CONTROL HANDLE
SECONDARY EJECTION CONTROL CABLE DISCONNECT PULLEY

AM.166
Figure 9-49.—Secondary ejection control handle.

rail hits the firing sear of the harness release actuator firing pin, arming the delay cartridge, located within the harness release actuator.

After a 1-second delay, the cartridge fires and performs two simultaneous actions: It ruptures the nitrogen storage bottle diaphragm, releasing dry nitrogen to inflate the separation bladders; and it rotates and locks the bellcrank assembly in its full up position.

The piston rod is attached to the bellcrank assembly by a clevis and pin arrangement. As the piston is impelled upward, the clevis strikes the firing control disconnect assembly actuating arm. When the arm is actuated, the ejection control handles are free to be separated from the seat.

Additional action of the bellcrank, when moved to the up position, retracts the shoulder harness disconnect cable to release the inertia reel straps and retracts the lap belt retaining pins from the seat structure to release the lap belt fittings.

Nitrogen gas travels through aluminum tubing to inflate the separation bladders, separating seat from occupant.

It should be noted that all functions of the separation system occur concurrently, rather than successively, in one instantanious procedure to release and forcibly separate the occupant from the seat. In the event of a crash landing, or under any circumstances when removing survival equipment from the aircraft, the emergency harness release handle, when pulled upward, releases the shoulder harness and lap belt straps allowing survival equipment removal without detonating the delay cartridge within the harness release actuator.

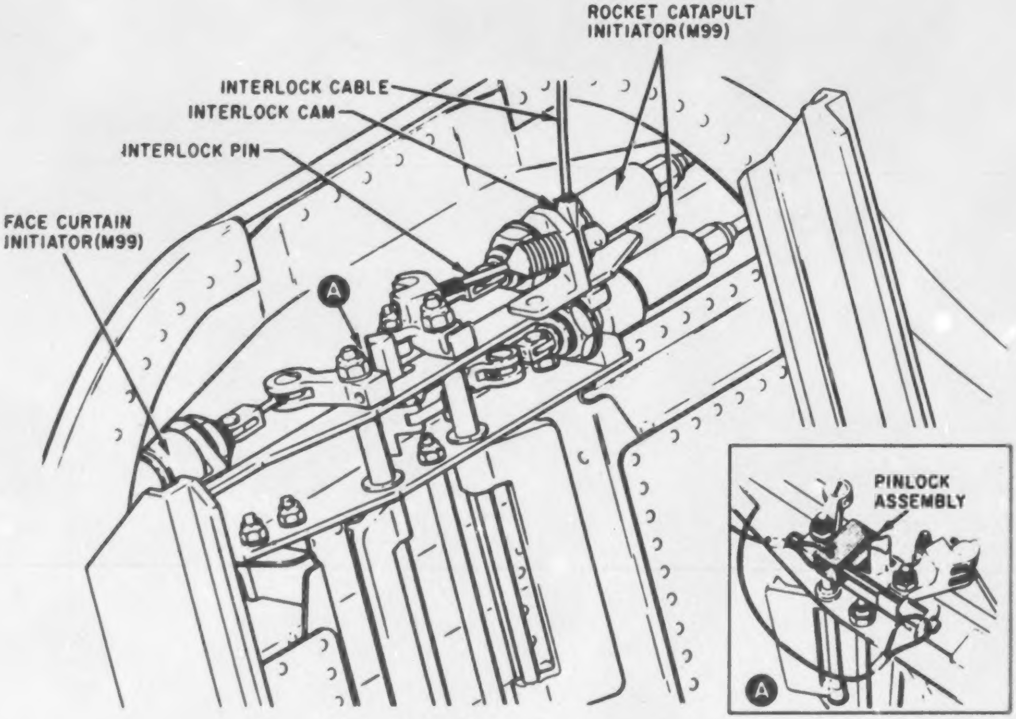
WARNING: The separation equipment includes the Mk 86 Mod 0 delay cartridge which is detonated by release of the sear on the firing pin assembly. Do not manually remove sear from firing pin assembly. Always remove entire firing pin assembly.

HARNESS RELEASE ACTUATOR.—The harness release actuator initiates the separation sequence during seat ejection. As shown in figure 9-52 the actuator consists of a T-shaped chamber. It houses a clevis and piston assembly within the longer vertical chamber, and a delay cartridge and firing pin assembly within the shorter horizontal chamber.

The harness release actuator performs three functions when the cartridge is fired: ruptures the nitrogen storage bottle diaphragm, actuates the firing control disconnect assembly, and positions the bellcrank assembly.

As the seat is ejected and travels upward along the guide rails, the sear on the firing pin assembly hits the striker plate on the right-hand guide rail, falls off and releases the spring-tensioned firing pin which strikes the delay cartridge. After the designed delay, the cartridge fires and drives the piston upward within the actuator.

The sharply pointed head of the piston ruptures the nitrogen storage bottle diaphragm, releasing the compressed dry nitrogen to inflate the separation bladders. The clevis assembly at the lower end of the piston strikes the firing control disconnect actuating arm in its travel upward, actuating the firing control disconnect assembly. Lastly, an arm of the bellcrank assembly, connected to the clevis, is rotated, positioning the bellcrank in a released position. This retracts the lap belt and shoulder harness release pins.



AM.1201

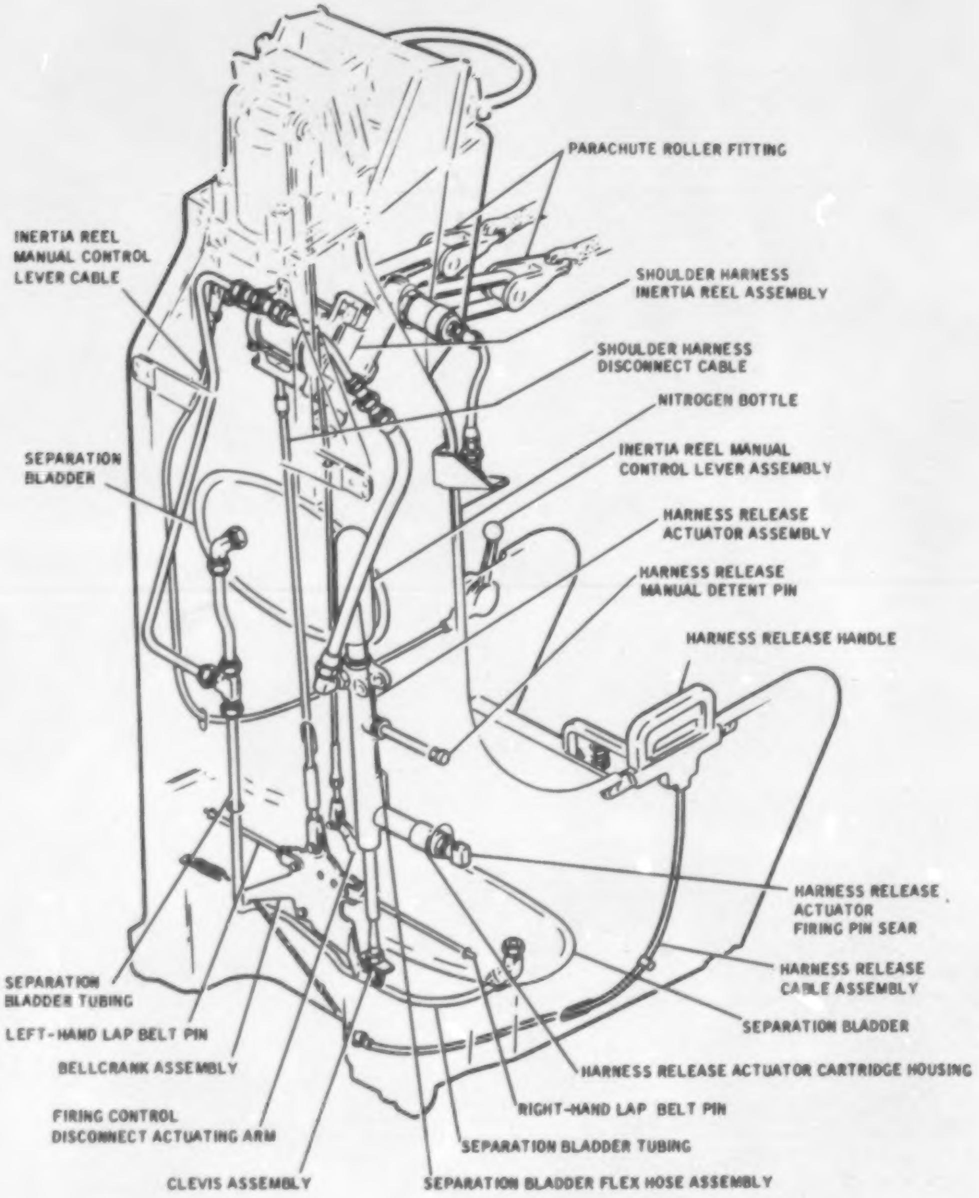
Figure 9-50.—Interlock cam and pin assembly—A-4F.

When the piston assembly is actuated by the delay cartridge, it travels its ultimate distance within the chamber of the actuator and is locked by two locking dogs. This insures that lap belt and shoulder harness pins remain retracted without the piston moving downward and causing the bellcrank to relock shoulder and lap belt strap fittings.

The harness release actuator can be partially actuated by the harness release handle on the right-hand arm of the ejection seat. Upon pulling this handle, which attaches by cable to the bellcrank assembly, the piston is moved upward into the actuator chamber. However, since a swaged fitting on the cable attaching to the harness release handle stops the handle from being pulled completely, the piston will not rise within the chamber sufficiently to pierce the diaphragm on the nitrogen storage bottle, nor will it lock in position on the locking dogs within the chamber. It will stay in the partially up position, held by a manual detent pin located at the upper end of the actuator. The manual detent pin protrudes through the right-hand side of the seat assembly. By pulling the manual detent pin, a return spring repositions the piston and bellcrank in their normal position.

HARNESS RELEASE ACTUATOR MANUAL DETENT PIN.—The harness release actuator manual detent pin, located below the nitrogen storage bottle on the harness release actuator, protrudes outboard of the actuator on the right-hand side of the seat structure. (See fig. 9-52.) The pin extends into the upper chamber of the actuator and locks the piston head in the harness release position when the harness release handle is pulled. The knob at the outboard end of the manual detent pin is manually pulled to depress the spring and release the harness release actuator piston.

The manual detent pin performs no function upon actuation of the delay cartridge during

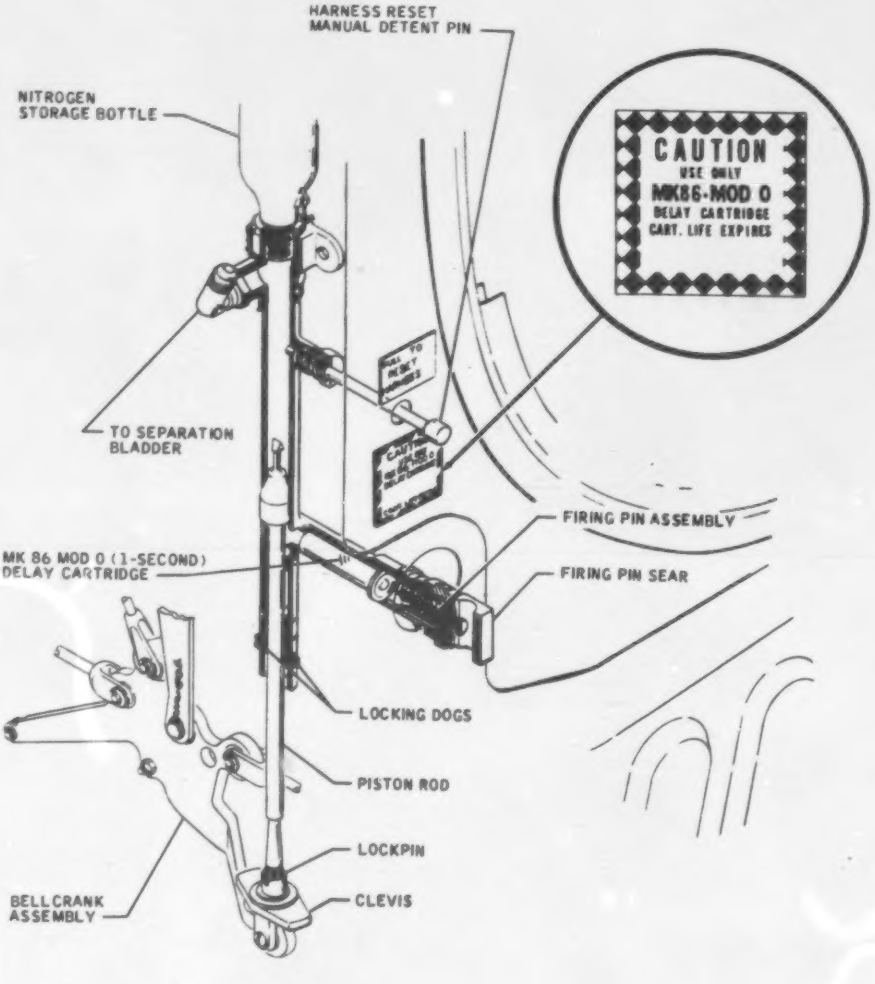

PARACHUTE ROLLER FITTING
INERTIA REEL MANUAL CONTROL LEVER CABLE
SHOULDER HARNESS INERTIA REEL ASSEMBLY
SHOULDER HARNESS DISCONNECT CABLE
NITROGEN BOTTLE
SEPARATION BLADDER
INERTIA REEL MANUAL CONTROL LEVER ASSEMBLY
HARNESS RELEASE ACTUATOR ASSEMBLY
HARNESS RELEASE MANUAL DETENT PIN
HARNESS RELEASE HANDLE
HARNESS RELEASE ACTUATOR FIRING PIN SEAR
HARNESS RELEASE CABLE ASSEMBLY
SEPARATION BLADDER
SEPARATION BLADDER TUBING
LEFT-HAND LAP BELT PIN
BELLCRANK ASSEMBLY
HARNESS RELEASE ACTUATOR CARTRIDGE HOUSING
FIRING CONTROL DISCONNECT ACTUATING ARM
RIGHT-HAND LAP BELT PIN
SEPARATION BLADDER TUBING
CLEVIS ASSEMBLY
SEPARATION BLADDER FLEX HOSE ASSEMBLY

AM.167

Figure 9-51.—Separation equipment.

ejection, as the piston head, at this time, travels beyond the detent pin; therefore, its operation is limited to manual only for removal or installation of the parachute and other survival equipment.

LOCKING DOGS.—The locking dogs are located at the lower end of the harness release actuator, and are designed to lock the piston with the actuator upon detonation of the delay


HARNESS RESET
MANUAL DETENT PIN
NITROGEN
STORAGE BOTTLE
CAUTION
USE ONLY
MK86-MOD 0
DELAY CARTRIDGE
CART. LIFE EXPIRES
TO SEPARATION
BLADDER
FIRING PIN ASSEMBLY
MK 86 MOD 0 (1-SECOND)
DELAY CARTRIDGE
FIRING PIN SEAR
LOCKING DOGS
PISTON ROD
LOCKPIN
BELLCRANK
ASSEMBLY
CLEVIS

AM.168

Figure 9-52.—Harness release actuator.

cartridge. The springs force the upper end of the locking dogs into engagement with the piston. The locking dogs lock and hold the piston within the actuator by engaging a shoulder at the lower tapered end of the piston. Locking will occur only upon firing of the delay cartridge since the piston never travels to this locked position when the harness release handle is utilized.

In the event of the accidental firing of the delay cartridge, causing the piston to be locked by the locking dogs, two 1/8-inch diameter rods can be inserted into the base of the locking dogs (at both sides) and, by depressing the dogs, the piston may be returned to its normal position. (see fig. 9-52.) The actuator must be replaced if accidentally fired.

HARNESS RELEASE ACTUATOR FIRING PIN ASSEMBLY.—The harness release actuator firing pin assembly (fig. 9-52), located in the firing chamber of the harness release actuator, consists of the following components: firing pin, spring, guide, hex nut, and sear. The firing pin is held in position by the sear which holds the tensioned firing pin in place. As the sear comes into contact with the striker plate on the right-hand guide rail, the sear is removed from the firing pin, allowing the firing pin to strike the delay cartridge, causing detonation and initiating the separations procedure.

HARNESS RELEASE ACTUATOR FIRING PIN GUARD.—The harness release actuator firing pin guard consists of two pieces of aluminum framing attached to the right-hand guide rail. The guard covers the firing pin assembly, connected to the harness release actuator, and insures against the possibility of accidental manual detonation of the delay cartridge by removal of the firing sear. The outer extension of the guard must be disconnected in order to remove the firing pin assembly from the actuator while the ejection seat is installed in the cockpit. Disconnecting two bolts and washers from nut plates on the guard will separate the extension and permit removal of the firing pin assembly.

STRIKER PLATE ASSEMBLY.—The striker plate assembly, located above midpoint on the right-hand guide rail, provides the means of removing the sear on the harness release actuator firing pin as the seat travels up the guide rails, actuating the firing pin and detonating the delay cartridge. The striker plate is spring tensioned and can be positioned aft to permit removal of the firing pin mechanism. The striker plate is bolted to the right-hand guide rail through either of two sets of mounting holes. It is subject to removal and installation only to insure a minimum clearance of 0.063 inch by the actuator sear in the depressed position and a minimum engagement of 0.312 inch with the actuator sear in the extended position.

MK 86 MOD 0 DELAY CARTRIDGE.—The MK 86 Mod 0 delay cartridge (when fired) creates sufficient gaseous pressure to raise the piston assembly within the harness release actuator to pierce the diaphragm on the nitrogen storage bottle. The cartridge has a delay action prior to detonation; that is, after the firing pin strikes the cartridge, a 1-second lapse occurs before cartridge explosion.

Service life of the Mk 86 Mod 0 delay cartridge is 5 years from the date of manufacture. The cartridge may not be installed longer than 18 months after opening the hermetically sealed container. The cartridge is subject to both the foregoing limitations.

NOTE: Several delay cartridges have the same dimensions and are physically interchangeable. However, the proper delay cartridge must be installed in the device for which it was designed; otherwise, improper time sequence could result in a casualty.

NITROGEN STORAGE BOTTLE.—The nitrogen storage bottle provides the means of inflating the two separation bladders on the ejection seat and is pressurized to 1,600 psi. The bottle is installed on top of the harness release actuator with a rupture fitting secured by lockwire. The bottle is also secured by lockwire to the harness release actuator assembly. (See fig. 9-52.) The requirement to lockwire the rupture fitting is dependent on the type bottle. Following the instructions provided in the MIM.

The nitrogen storage bottle is sealed with a metal rupture fitting which is punctured by the pointed end of the harness release actuator as the Mk 86 Mod 0 delay cartridge is fired.

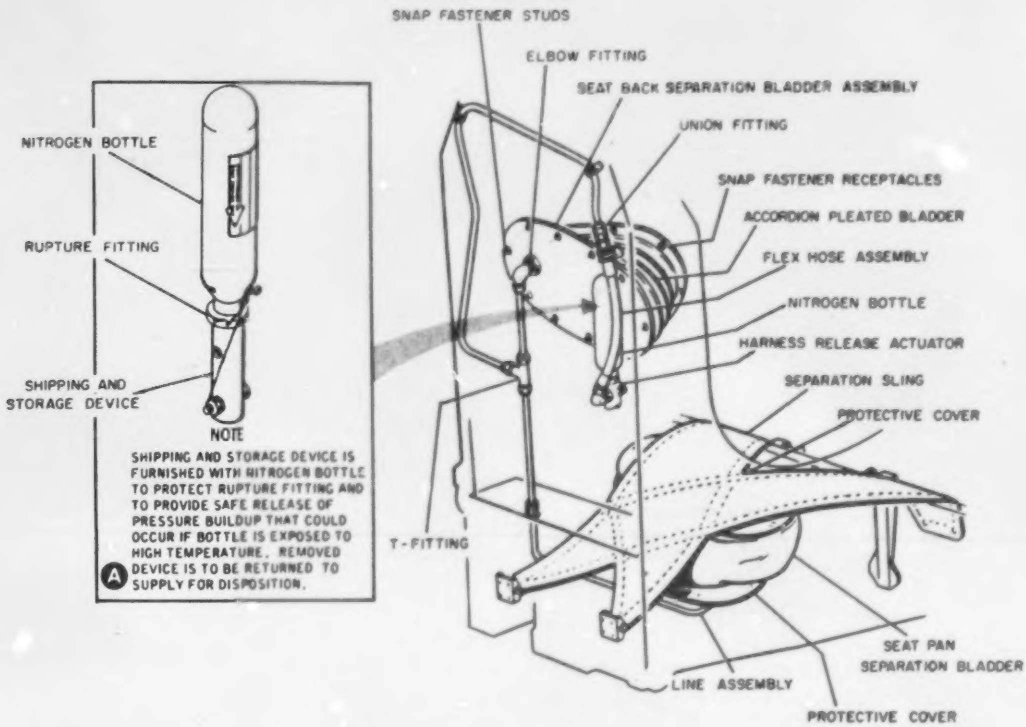
Upon rupturing, compressed dry nitrogen is released into a hose and line assembly to inflate the separation bladders. An inspection hole is provided on the front seat structure to determine whether a bottle is installed when the seat is installed in the aircraft.

WARNING: In the event of accidental actuation of the Mk 86 Mod 0 delay cartridge, the nitrogen storage bottle must be replaced. Failure to comply will present a serious hazard upon seat ejection.

SEPARATION BLADDERS.—Two separation bladders on the ejection seat, fabricated of latex impregnated nylon, are folded against the seat bucket and seat back structure. (See fig. 9-53.) The bladders are connected to the seat with right-angle special fittings secured in place with jamnuts, lockwired to the connecting metal tubing. The bladder fittings protrude from the back of the seat and connect through lines to the outlet port on top of the harness release actuator.

The separation bladders are covered with oval-shaped, rubberized snap covers fitted into studs attached to the seat structure. As the bladders fill with nitrogen gas, the snap cover fittings detach from the seat structure, allowing bladders to fully inflate. The inflated bladders lift the pilot up and away from the seat. Immediate escape of pilot from seat is essential during low-level ejections.

WARNING: Do not step or stand upon separation bladder on base of seat with survival equipment removed during maintenance in cockpit area. Cover base of seat assembly with foam rubber or cloth pad before standing in seat assembly.


SNAP FASTENER STUDS
ELBOW FITTING
SEAT BACK SEPARATION BLADDER ASSEMBLY
UNION FITTING
SNAP FASTENER RECEPTACLES
ACCORDION PLEATED BLADDER
FLEX HOSE ASSEMBLY
NITROGEN BOTTLE
HARNESS RELEASE ACTUATOR
SEPARATION SLING
PROTECTIVE COVER
T-FITTING
SEAT PAN
SEPARATION BLADDER
LINE ASSEMBLY
PROTECTIVE COVER
NITROGEN BOTTLE
RUPTURE FITTING
SHIPPING AND
STORAGE DEVICE
A

NOTE

SHIPPING AND STORAGE DEVICE IS FURNISHED WITH NITROGEN BOTTLE TO PROTECT RUPTURE FITTING AND TO PROVIDE SAFE RELEASE OF PRESSURE BUILDUP THAT COULD OCCUR IF BOTTLE IS EXPOSED TO HIGH TEMPERATURE. REMOVED DEVICE IS TO BE RETURNED TO SUPPLY FOR DISPOSITION.

AM. 169

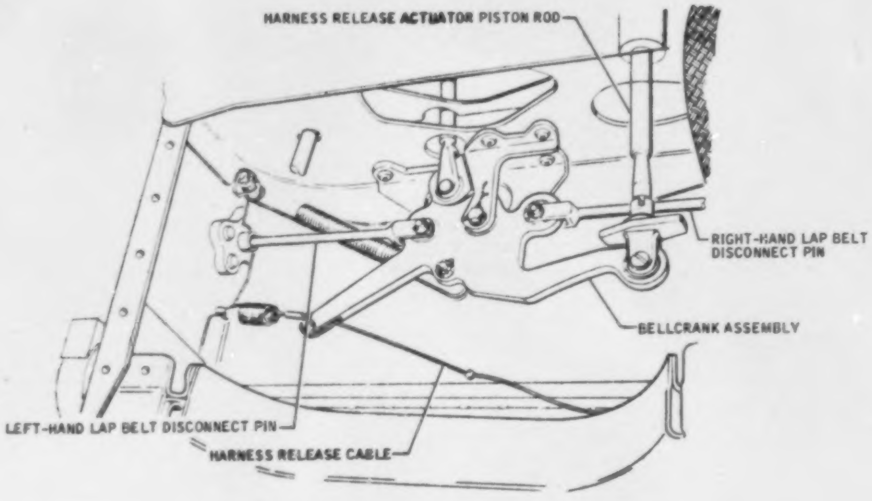
Figure 9-53.—Separation bladders.

HARNESS RELEASE BELLCRANK ASSEMBLY.—The harness release bellcrank assembly, located at the lower back of the seat structure, consists of a dual-arm leverage assembly, containing attachments which immediately sever all connections of pilot from seat upon firing of the harness release actuator. Connections from the bellcrank assembly (fig. 9-54) are made to the following components:

1. The clevis assembly of the release actuator.
2. Right and left lap belt retaining pins, holding lap belts to seat.
3. Shoulder harness disconnect cable (release shoulder harness straps).
4. Harness release handle cable (actuates bellcrank for manual harness release).
5. Return spring (to reposition bellcrank upon actuation of harness reset manual detent pin).

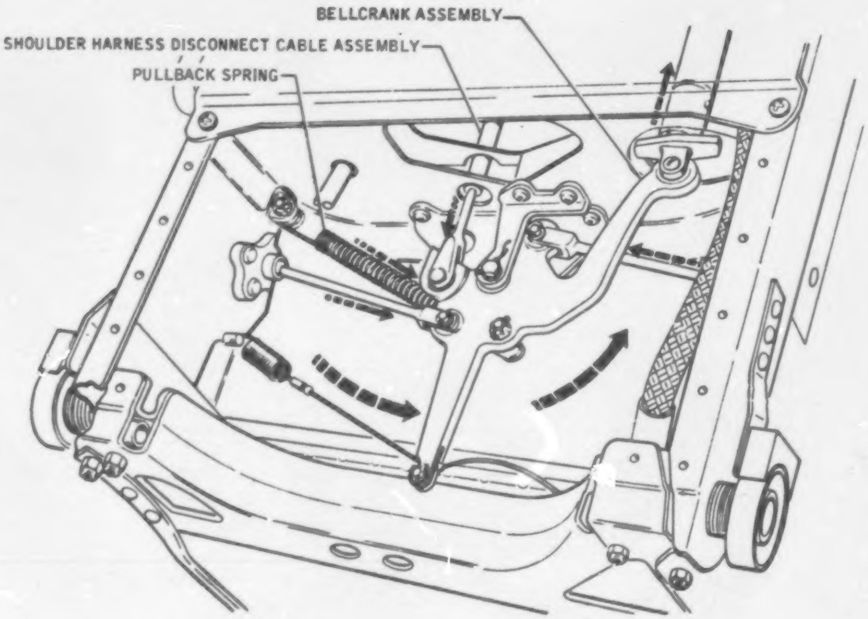
Connected by one arm to the base of the clevis assembly, the harness release bellcrank assembly repositions as the clevis rises within the actuator upon seat ejection. Repositioning moves all components into a released position; the shoulder harness inertia reel straps and the left and right lap belt pins release as the clevis piston travels upward. Figure 9-55 shows the bellcrank in the fired position.

Actuation of the bellcrank may also be effected through the harness release handle on the right-hand side of the seat assembly, which, when pulled upward, moves the bellcrank to the released position, forcing the clevis upward into the harness release actuator, and locking it with the harness release actuator manual detent pin. Manually pulling the detent pin, protruding from the right-hand side of the seat assembly, resets the entire mechanism into its normally locked position.


HARNESS RELEASE ACTUATOR PISTON ROD
RIGHT-HAND LAP BELT DISCONNECT PIN
BELLCRANK ASSEMBLY
LEFT-HAND LAP BELT DISCONNECT PIN
HARNESS RELEASE CABLE

AM. 170

Figure 9-54.—Harness release bellcrank—static position.


BELLCRANK ASSEMBLY
SHOULDER HARNESS DISCONNECT CABLE ASSEMBLY
PULLBACK SPRING

AM. 171

Figure 9-55.—Harness release bellcrank—fired position.

LAP BELT RETAINING PINS.—The lap belt retaining pins attached to the harness release bellcrank are long rods which extend outboard from the bellcrank into the left and right structure of the seat assembly, protruding one-sixteenth inch from the sides of the seat when the bellcrank is in its normally locked position. The lap belt retaining pins secure the lap belt end fittings to the seat during normal flight operations.

Upon seat ejection, actuation of the bellcrank will reposition retaining pins into an unlocked position by setting them upward and inboard toward the central portion of the seat structure. The retaining pins will remain in the released position as the bellcrank locks into the harness release actuator by the piston upon firing of the delay cartridge within the actuator. Lap belt end fittings are then no longer locked to the seat structure and pull away to permit the separation of pilot and seat.

SHOULDER HARNESS INERTIA REEL ASSEMBLY.—The shoulder harness inertia reel assembly (fig. 9-56) consists of an inertia reel located in the lower headrest area of the ejection seat and a control assembly on the left-hand side of the seat bucket. A flexible control cable couples the two units and permits manual locking and release of the inertia reel. The straps are able to withstand severe tensile loads with complete safety.

Normally, the inertia reel will extend or retract automatically; however, when the aircraft encounters excessive g forces that tend to throw the occupant from the seat, such as in a crashlanding condition, the reel automatically locks the shoulder harness, regardless of the occupant's position. This locking action prevents further harness extension, but permits the occupant to return to a normal sitting position and, at the same time maintains locking action.

On the A-4F aircraft, the inertia reel is of the powered type. It provides automatic power retraction of the straps upon initiation of the ejection sequence to insure optimum body positioning.

INERTIA REEL MANUAL CONTROL LEVER ASSEMBLY.—The inertia reel manual control lever assembly provides instant selection of either the locked or the unlocked position. The control assembly, located on the left-hand side of the seat bucket, is a spring-tensioned lever (fig. 9-56).

Under normal conditions the control lever assembly will be in the LOCKED position for takeoff and landing. It will otherwise be placed in the UNLOCKED position during normal flight for greater freedom of movement. During adverse flying conditions, the reel can be locked by placing the control lever in the LOCKED position. Locking the inertia reel prevents extension of the harness straps and secures the pilot firmly against the seat back. Quick retraction of the harness straps will not affect the LOCKED or UNLOCKED attitude of the reel.

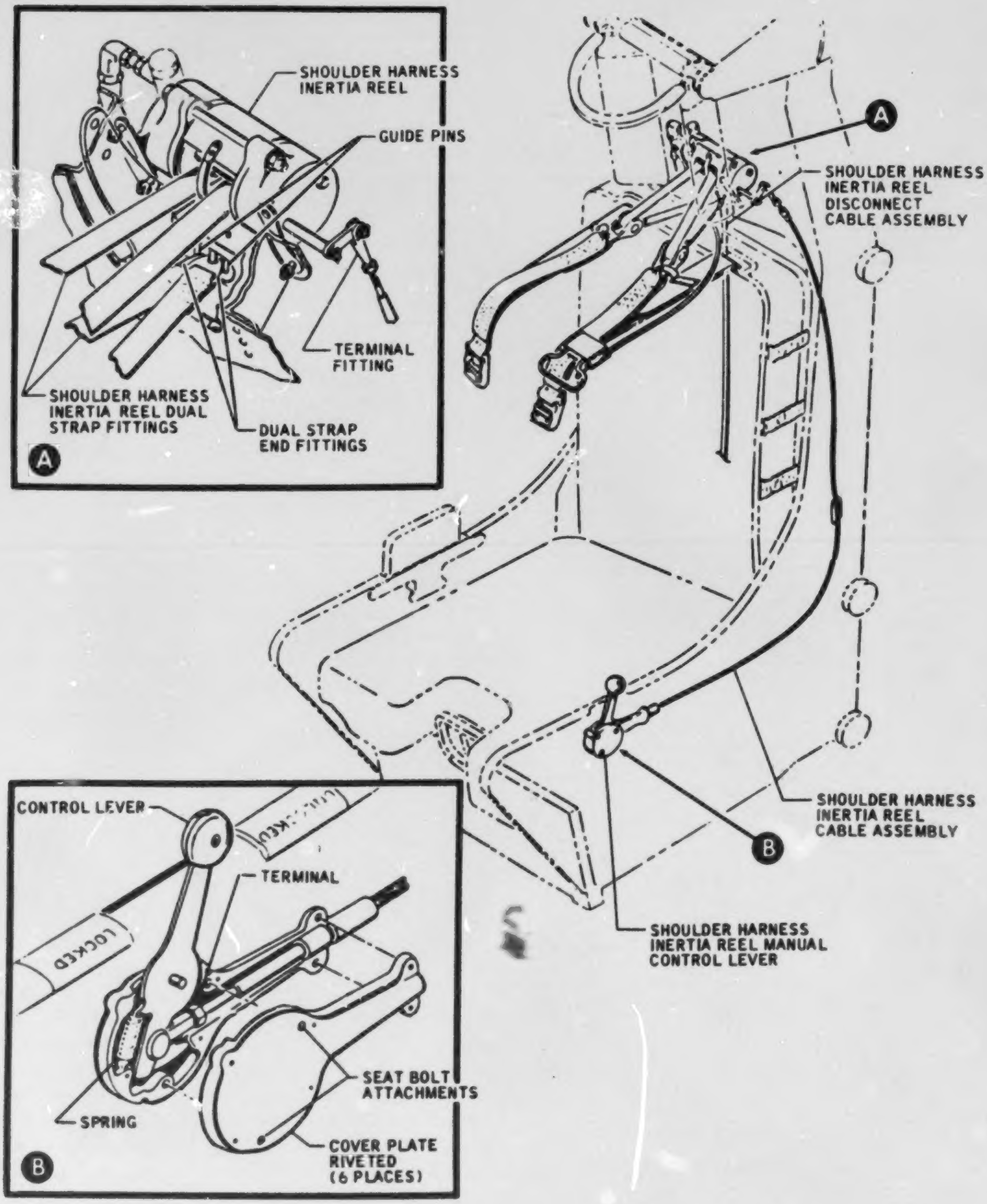
SHOULDER HARNESS DISCONNECT CABLE ASSEMBLY.—The shoulder harness disconnect cable assembly (fig. 9-56) provides a means of securing the shoulder harness inertia reel straps to the seat structure. The upper end of the cable assembly is attached to a pin that is normally contained in a recess located in the seat structure. The lower end of the cable is attached to the bellcrank assembly. When the bellcrank is rotated, the cable pulls the pin downward a sufficient distance to release the inertia reel dual strap fittings.

Two holes are located in the seat back structure to permit a direct vertical attachment of the cable from the pin to the bellcrank. The cable is routed from the pin through a hole located below the pilot's headrest. The cable travels down the forward side of the seat back, passes through a hole at the lower end of the seat back, and is attached to an arm of the bellcrank assembly.

The shoulder harness disconnect cable pin is normally in a locked position; that is, fixed through the integral strap attach fitting beneath the inertia reel on the seat structure. However, as the seat ejects, the delay cartridge fires, in turn, repositioning the bellcrank, which draws the shoulder harness disconnect cable pin downward. This opens the attach fitting and frees the inertia reel straps, permitting them to pull through the parachute roller fittings into the inertia reel. The pilot is free of any attachment to the seat and separation is made possible.

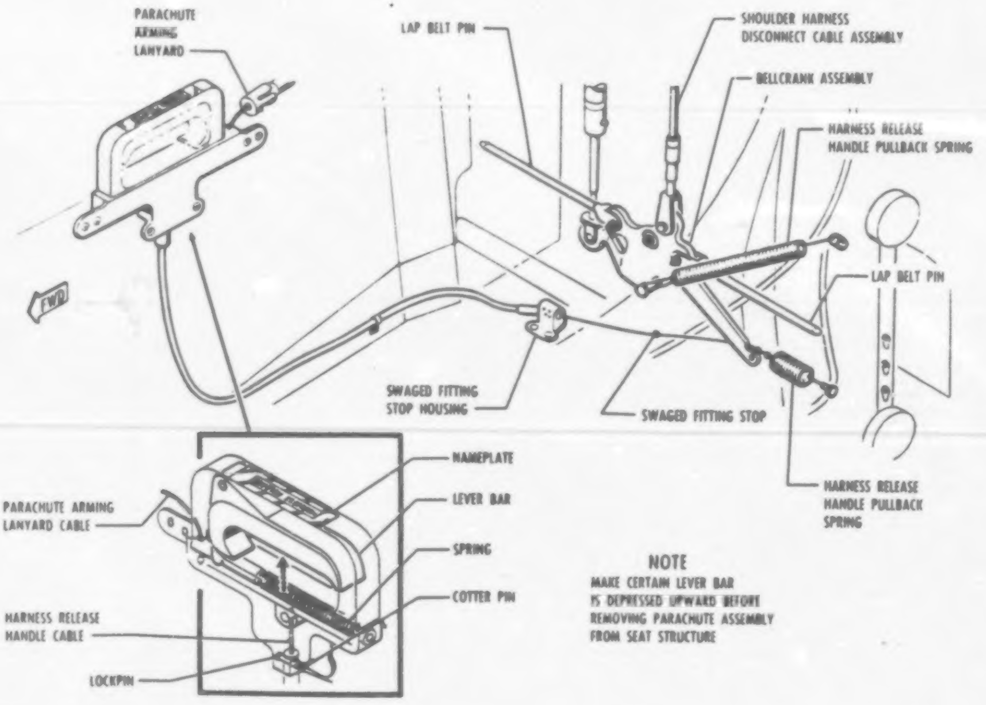
HARNESS RELEASE HANDLE.—The harness release handle (fig. 9-57) is located in a holder on the right side of the seat assembly, and provides a means of manually releasing all restraining components of the ejection seat by partially actuating the bellcrank located in the lower aft portion of the seat assembly.

The handle contains a release clip and a spring and pin assembly. The spring and pin assembly positions and locks the parachute arming


SHOULDER HARNESS INERTIA REEL
GUIDE PINS
TERMINAL FITTING
SHOULDER HARNESS INERTIA REEL DUAL STRAP FITTINGS
DUAL STRAP END FITTINGS
A
A
SHOULDER HARNESS INERTIA REEL DISCONNECT CABLE ASSEMBLY
CONTROL LEVER
TERMINAL
LOCKED
SEAT BOLT ATTACHMENTS
SPRING
COVER PLATE RIVETED (6 PLACES)
B
B
SHOULDER HARNESS INERTIA REEL CABLE ASSEMBLY
SHOULDER HARNESS INERTIA REEL MANUAL CONTROL LEVER

AM. 172

Figure 9-56.—Shoulder harness power inertia reel assembly.


PARACHUTE ARMING LANYARD
LAP BELT PIN
SHOULDER HARNESS DISCONNECT CABLE ASSEMBLY
BELLCRANK ASSEMBLY
HARNESS RELEASE HANDLE PULLBACK SPRING
FWD
LAP BELT PIN
SWAGED FITTING STOP HOUSING
SWAGED FITTING STOP
NAMEPLATE
LEVER BAR
PARACHUTE ARMING LANYARD CABLE
SPRING
COTTER PIN
HARNESS RELEASE HANDLE CABLE
LOCKPIN
HARNESS RELEASE HANDLE PULLBACK SPRING
NOTE
MAKE CERTAIN LEVER BAR IS DEPRESSED UPWARD BEFORE REMOVING PARACHUTE ASSEMBLY FROM SEAT STRUCTURE

AM. 173

Figure 9-57.—Harness release handle.

lanyard into place. As the release clip within the handle is lifted upward, the pin and spring are depressed, releasing the lanyard. The handle base forms a holder for a cable that is attached to the bellcrank. The cable is held in place with a swaged ball fitting attached by a spring to the left side of the seat structure.

A metal stop holder, attached to the lower shelf of the seat assembly, holds the flex cable in position while providing a stop for the swaged cable fitting and limits travel of the manual harness release system.

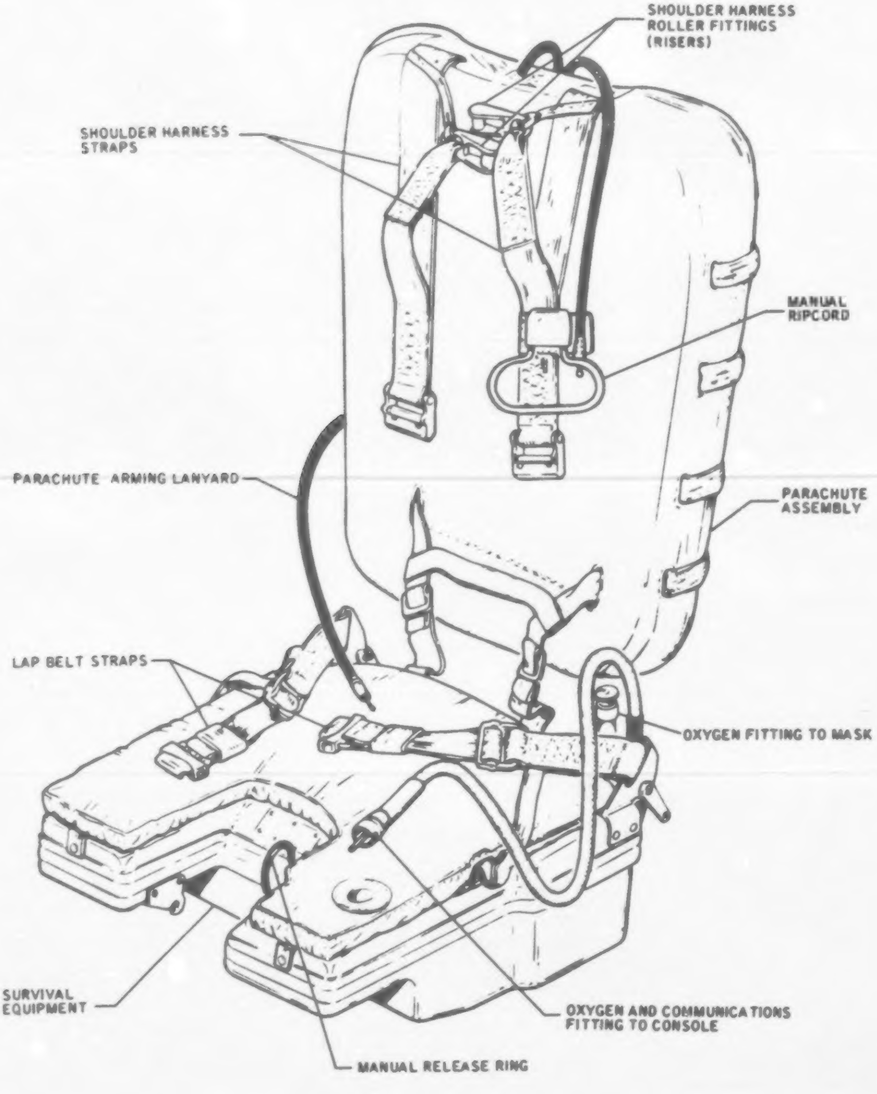
As the release clip within the handle is raised, the parachute arming lanyard is released. As the handle itself is raised, the cable is pulled upward which, in turn, pulls the left arm of the bellcrank downward. Downward movement of the left arm raises the actuator piston upward into the harness release actuator. At the same time, the bellcrank retracts the left and right lap belt pins and the shoulder harness pin attachments. The piston, which moves upward into the harness release actuator, is locked in the released position by the manual detent pin on the right side of the actuator.

To prevent further travel upward when using the harness release handle, a swaged fitting, attached to the harness release handle cable assembly, positions against the metal stop holder on the lower shelf of the seat. This insures against the possibility of rupturing the nitrogen storage bottle diaphragm when using the harness release handle.

To reposition the handle into the seat assembly holder, the manual detent pin must be pulled outboard to reset the bellcrank which, in turn, resets the harness release cable.

Survival Equipment

The survival equipment (fig. 9-58) consists of all equipment used by the pilot after ejection from the aircraft has been effected, permitting a safe return to ground level and, if ejection

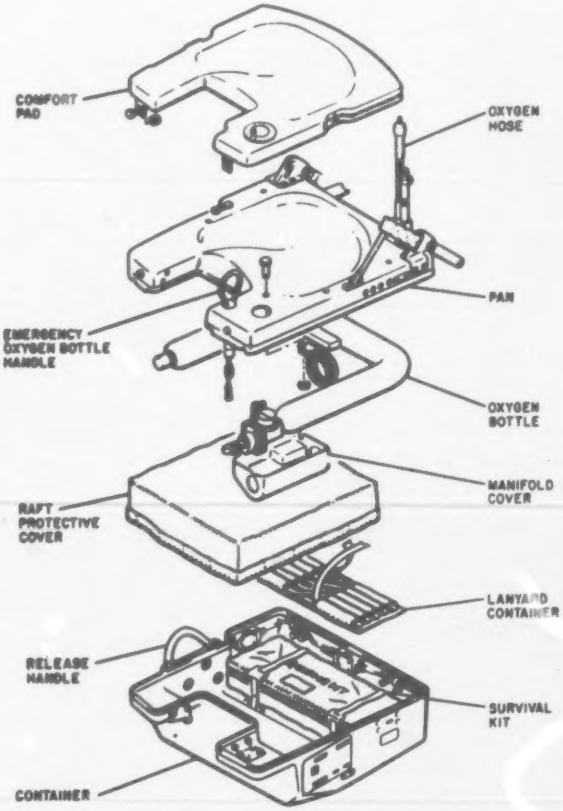

SHOULDER HARNESS ROLLER FITTINGS (RISERS)
SHOULDER HARNESS STRAPS
MANUAL RIPCORD
PARACHUTE ARMING LANYARD
PARACHUTE ASSEMBLY
LAP BELT STRAPS
OXYGEN FITTING TO MASK
SURVIVAL EQUIPMENT
OXYGEN AND COMMUNICATIONS FITTING TO CONSOLE
MANUAL RELEASE RING

AM. 174

Figure 9-58.—Survival kit and parachute.

occurs at sea, subsistence until rescue operations can be conducted. The survival equipment includes the survival kit, the parachute assembly, and the anti-exposure suit. The AME is responsible for removal and installation of the survival kit and parachute in the aircraft.

SURVIVAL KIT.—The survival kit assembly (fig. 9-59) consists of an interconnected, two-piece container and a cushion that provides a seat for the pilot. Oxygen system components for emergency operations are mounted within the container. In addition, space is available for a liferaft and survival equipment bag. A flexible personal oxygen and communications lead is attached to the kit by a multipurpose quick-disconnect fitting. During normal operations, the



AM. 1202

Figure 9-59.—Seat and survival kit assembly—A-4F.

pilot attaches his survival kit to his parachute harness by means of the two straps connected to the back side of the container.

The emergency oxygen bottle is actuated automatically by a cable attached to the cockpit structure as the ejection seat moves up the rails during ejection. The emergency oxygen bottle can also be actuated manually by pulling the green ring located on the inboard side of the left-hand thigh support on the seat pad assembly. When either method is utilized, the respective cable pulls a yoke attached to the pressure regulator valve of the bottle, which in turn releases a plunger to actuate the bottle.

ANTIEXPOSURE SUIT.—The antiexposure suit is designed for use by personnel on flights where unprotected or prolonged exposure to the conditions of cold air or water, as a result of abandoning the aircraft, would be hazardous and could be fatal. The protection afforded by the suit can be extended by using an inflatable hood and gloves to keep the head and hands warm.

The suit utilizes conditioned or cockpit air for ventilation to provide pilot comfort in flight.

Ejection Seat Safety Equipment

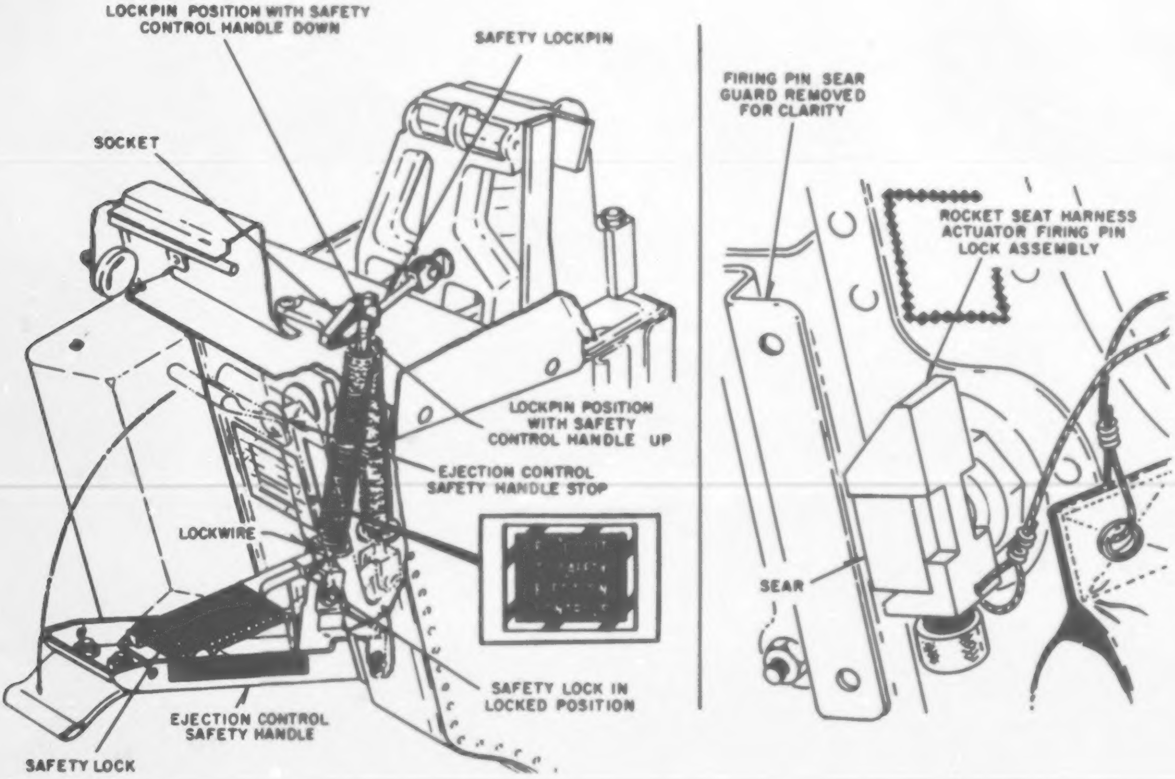
The rocket catapult ejection seat (ESCAPAC 1-C3) contains explosive charges that represent a potential danger to personnel responsible for maintenance of the seat and the equipment contained in the cockpit area. To afford a measure of safety to both personnel and equipment, three safety devices are provided for installation on the seat when the aircraft is on the ground.

These safety devices are the pin block assembly used in the interlock mechanism as shown in figure 9-50, initiator safety pins, and the rocket harness actuator lock assembly. The interlock cam and pin assembly (fig. 9-50) and the ejection control safety handle are integral components of the seat and provide additional protection against inadvertent firing of the rocket charge causing seat ejection. Figure 9-60 illustrates the ejection control handle and the harness actuator firing pin lock assembly.

The ejection control safety handle prevents rotation of the firing control disconnect assembly, precluding ejection seat initiation. When the safety handle is moved to the DOWN position, a cam attached to a safety rod (fig. 9-60) moves the rod upwards and into the ground safety socket. All ejection movements of the firing controls are stopped.

To secure the pin in the locked position, a safety lock is incorporated into the handle assembly. With the handle DOWN, the safety lock, which is spring loaded at the pivot point, moves upward to engage a stop attached to the seat structure. The handle cannot be moved to the UP position until the safety lock is manually depressed to disengage the lock from the stop. The safety lock becomes visible when the ejection control handle is in the DOWN position. The upper surface of the lock is covered with a black and yellow checkerboard decal to provide visual verification that the ejection controls are safely secured in the locked position.

With the exception of the rocket seat safety harness actuator lock assembly, which is installed before removal and installation of the


LOCKPIN POSITION WITH SAFETY CONTROL HANDLE DOWN
SAFETY LOCKPIN
SOCKET
LOCKPIN POSITION WITH SAFETY CONTROL HANDLE UP
EJECTION CONTROL SAFETY HANDLE STOP
LOCKWIRE
SAFETY LOCK IN LOCKED POSITION
EJECTION CONTROL SAFETY HANDLE
SAFETY LOCK
FIRING PIN SEAR GUARD REMOVED FOR CLARITY
ROCKET SEAT HARNESS ACTUATOR FIRING PIN LOCK ASSEMBLY
SEAR

AM. 1203

Figure 9-60.—Ejection seat safety equipment.

ejection seat from the cockpit, all safety devices must be in place and properly positioned when the aircraft is on the ground.

All safety devices, except those integrated into the seat construction, are provided with red streamers. Before entering the cockpit for maintenance purposes, all safety equipment must be visually checked to make certain each item is installed and secured. All personnel entering the cockpit area must be properly instructed in the use of the safety equipment and warned of the highly dangerous nature of the explosives contained in the rocket catapult ejection seat.

WARNING: The seat ejection and canopy jettison systems are interelated. Detonation of the ejection seat explosive charges or inadvertent actuation of the canopy initiators can cause serious injury or loss of life. All personnel concerned with operation or maintenance of the rocket ejection seat must be throughly familiar with both systems.

Maintenance

Maintenance of the ESCAPAC 1-C3 ejection system consists of parts removal, inspection, repair, replacement, installation, and functional testing and leak testing of designated components as specified in the Maintenance Instructions Manual and the Maintenance Requirements Cards.

The seat separation bladder assemblies, the DART stabilization and snubbing system, the rocket catapult, the harness release actuator cartridge, the power inertia reel cartridge, and ejection system initiators are subjected to removal and replacement after a specified time interval expressed in either operating hours or or length of time in service as specified in the Periodic Maintenance Information Cards (PMIC) and NavAir 11-100-1.

WARNING: Make certain all ground handling safety equipment is installed on the ejection seat and system initiators before starting any work in the cockpit area.

When work in the cockpit requires removal of the survival equipment from the ejection seat, the specially designed separation bladder protective cover should be installed to prevent damage.

Procedures for handling of system initiators are the same as for the canopy initiators discussed earlier in this chapter. No maintenance is allowed on the initiators except removal and replacement. Attempts to remove the initiator cartridges are strictly prohibited.

All components of the ejection seat requiring lubrication are serviced at each calendar inspection. If removal of a component is required between inspections for any reason, it must be lubricated at the time of installation. Lubrication information is provided in the General Information and Servicing volume of the applicable Maintenance Instructions Manual.

Proper operation of the ejection seat can only be assured when all maintenance and subsequent quality assurance inspection is performed exactly as specified in the applicable Maintenance Instructions Manual. Procedures for checking, testing, adjusting, and removing and replacing parts along with drawings, pictures, diagrams, etc. necessary to prevent improper installation are provided in the MIM and MUST be used to insure a flight-ready ejection seat.

The inspection requirements for the ESCAPAC 1-C3 ejection seat as listed in the calendar inspection Maintenance Requirements Cards do not always include all the specific procedures for satisfying a requirement. The AME must consult the Maintenance Instructions Manual to insure correct step-by-step procedures are followed.

The maintenance requirements for the ESCAPAC 1-C3 discussed in this section are not to be used in performing seat maintenance. It is intended to provide information concerning typical ejection seat maintenance practices.

SEAT REMOVAL.—The procedures for removal of the ESCAPAC ejection seat for inspection are similar to the procedures discussed for the Martin-Baker seats. The seat must be dearmed to the extent possible and safetied as directed in the MIM. Disconnect all seat-to-aircraft connections. A force gage, attached to the seat at the seat-to-catapult gun-attachment fitting, is used to check the force required to lift the seat up the guide rails. The initial breakaway force and the lifting force must be within the tolerances specified.

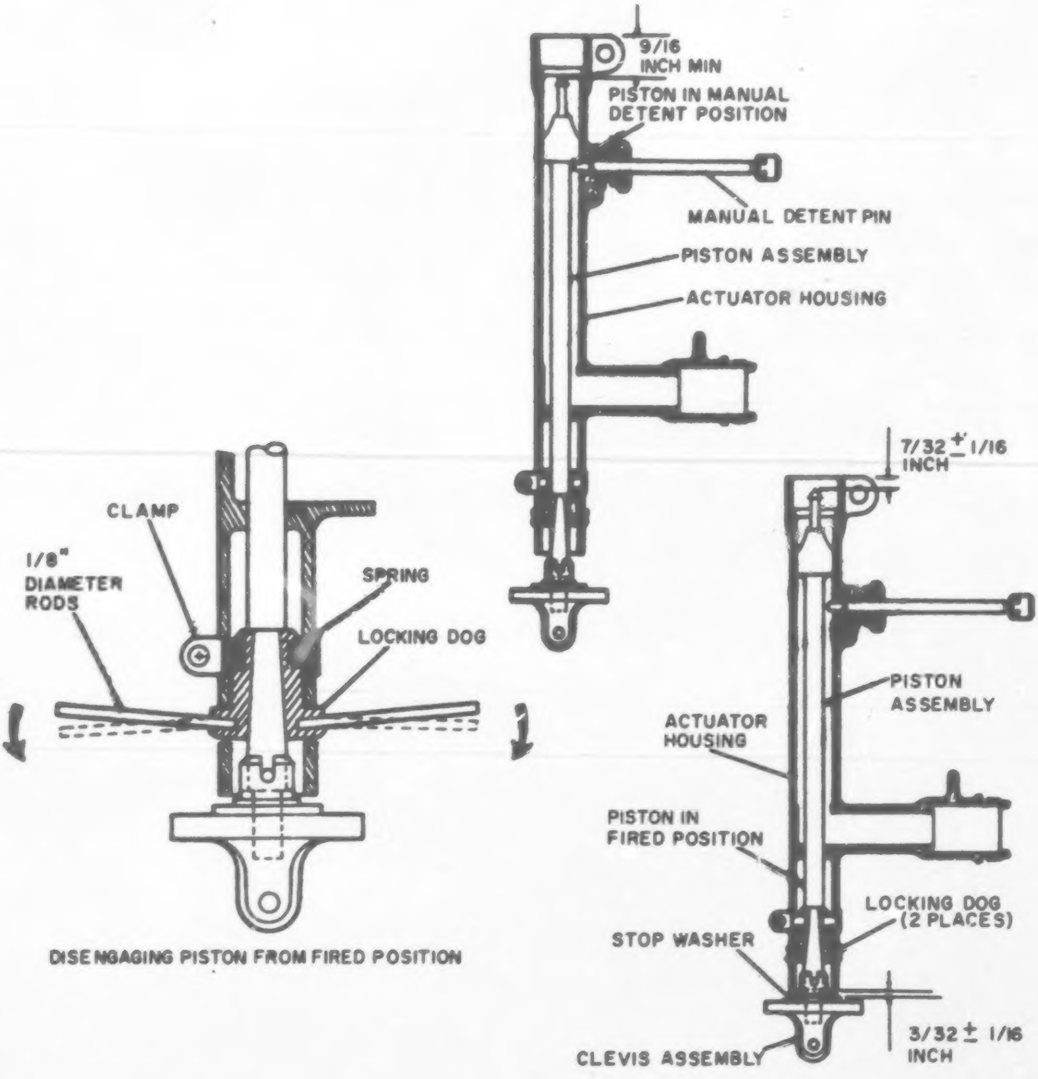
The striker assembly mounted on the right-hand guide rail must be depressed as the seat is raised up the rails to prevent bending of the shaft of the harness release actuator firing pin (firing pin lock assembly installed). If the firing pin lock assembly is not installed, the striker assembly must be depressed as the seat is raised up the rails to prevent accidental firing of the harness release actuator cartridge and mechanism.

HARNESS RELEASE ACTUATOR CARTRIDGE REMOVAL.—The harness actuator lock assembly (fig. 9-60) is removed from the actuator firing pin to accommodate removal of the MK 86 Mod 0 harness release actuator delay type cartridge. The cartridge is checked for damage, corrosion, and service life expiration date, then turned over to ordnance personnel for storing until needed during the seat buildup.

NITROGEN BOTTLE.—Prior to performing further maintenance, the nitrogen bottle is removed from the harness release actuator assembly. It is weighed to check for proper charge. The rupture fitting is also checked for damage. If the bottle is acceptable for reinstallation, it is capped and stowed until needed.

SEAT STRUCTURE INSPECTION.—The seat is checked for obvious damage such as cracks, loose or missing rivets, deformation, and corrosion. The seat rollers are checked for freedom of rotation and allowable clearance between the guide rails. Improper roller spacing could result in too much seat side play or binding of the seat during up and down movement or ejection. Roller spacing is adjusted by adding or removing shims between the roller and the seat.

HARNESS RELEASE ACTUATOR.—The harness release actuator is disassembled and subjected to close inspection for corrosion and general condition. The firing pin is disassembled and checked with a go-no-go gage. The pin must not be too long or too short. Either case would be cause for replacement. The harness release actuator piston assembly is released from the actuated (fired) position by inserting two 1/8-inch rods into the holes provided in each locking dog and pressing them down simultaneously as shown in figure 9-61. A complete


9/16
INCH MIN
PISTON IN MANUAL
DETENT POSITION
MANUAL DETENT PIN
PISTON ASSEMBLY
ACTUATOR HOUSING
7/32 ± 1/16
INCH
CLAMP
1/8"
DIAMETER
RODS
SPRING
LOCKING DOG
PISTON
ASSEMBLY
ACTUATOR
HOUSING
PISTON IN
FIRED POSITION
LOCKING DOG
(2 PLACES)
STOP WASHER
DISENGAGING PISTON FROM FIRED POSITION
3/32 ± 1/16
INCH
CLEVIS ASSEMBLY

AM. 1204

Figure 9-61.—Harness release actuator piston check.

functional check of the actuator and the harness release handle is required.

HARNESS RELEASE HANDLE CHECK.—With the harness release actuator reassembled, except for the installation of the nitrogen bottle and cartridge, and the harness actuator firing lock assembly installed, the harness release handle is functional tested as follows:

Pull the release handle from its holder. Attach a force gage (0 to 100 pounds) to the handle and slowly pull the handle until the manual detent pin engages the actuator piston in the detent position. The handle pull force should not have to exceed 40 pounds. The handle should have a minimum overtravel of 1/8 inch from the manual detent position.

If excessive force is required, the handle assembly is lubricated and rechecked. If excessive force is still required, the assembly is replaced.

Continue the test by pulling up on the handle with a force of 30 pounds until all overtravel from the manual detent position is taken up. Hold this force and have a second AME measure the distance from the actuator piercing point to the top of the housing as shown in figure 9-61. Distance must be a minimum of 9/16 inch.

Stow the handle in its holder and with the actuator in the manual detent position insure that the lap belt and shoulder harness retaining pins are withdrawn. Manually retract the actuator piston until the actuator clevis strikes the firing control disconnect actuating arm and the piston detents in the fired position (locking dogs locked). The firing control disconnect pin should be retracted, releasing the firing control disconnect fitting and allowing the ejection control cables to be drawn free. With the actuator in this position, the distance between the top of the actuator housing and the actuator piston piercing point should be approximately 7/32 inch. Proper overtravel of the piston is checked by measuring the distance from the bottom of the actuator housing to the top surface of the stop washer on the actuator clevis. Measurement should be approximately 3/32 inch as specified in the MIM.

The actuator piston is then returned to the fully extend position as previously explained. The harness lap belt and shoulder harness locking pins should protrude through their respective holes 1/16 inch exclusive of the tapered end. This completes the test of the harness release handle and the actuator.

SHOULDER HARNESS INERTIA REEL.—The functional checkout for the inertia reel includes checking for proper locking and unlocking, full extension measurement of the reel straps, and retraction force and full retraction of straps.

The inertia reel cartridge must be removed and checked for service life expiration date, condition, and proper length.

FACE CURTAIN HANDLE CHECK.—Maintenance on the face curtain ejection control handle assembly includes removal and installation, disassembly, reassembly, and testing during calendar inspection or when replacement or rework of the curtain and cables is necessary.

The operational check of the face curtain requires removal of the firing controls cover. The ejection control safety handle must be in the full DOWN position. A force gage is attached to the center of the face curtain handle and pulled straight out to check the force required to disengage the handle from the detents. Figure 9-62 shows the face curtain, the handle detent, and the firing control disconnect fitting.

The force required to disengage the handle is 25 (±5) pounds. The force is governed by the spring contained in the handle guide tube.

Next, push the ejection control safety handle to the full UP position and pull the face curtain out until the safety lockpin bottoms out in the socket. Retract the pin in the bottom of the firing control disconnect fitting assembly by pulling down on the cable. The face curtain and the cables should disengage from the seat.

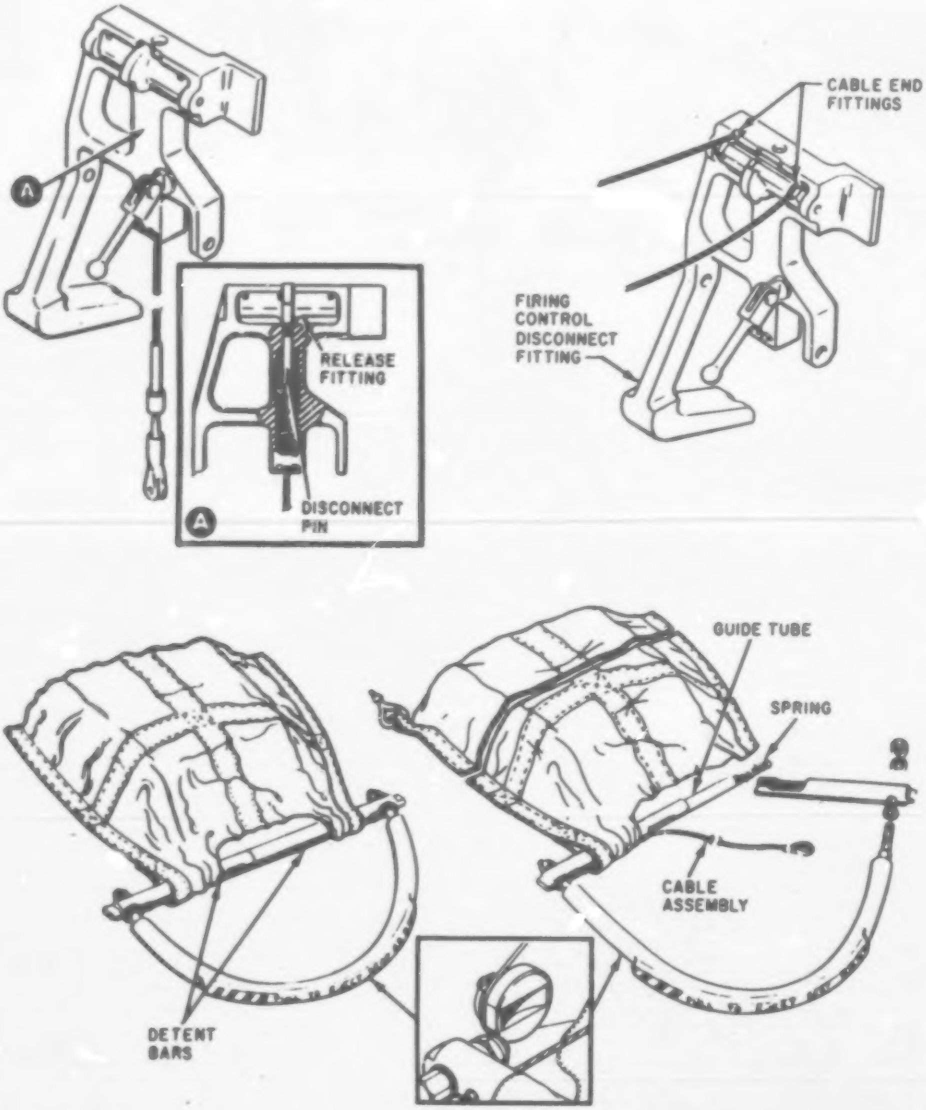
The face curtain assembly is then reinstalled in the seat. Make sure that the face curtain is in acceptable condition and that the service life of the curtain will not expire prior to the next scheduled inspection. Place the ejection control safety handle in the full DOWN position and feed the face curtain cables through the grommets in the curtain assembly storage compartment. Pull down on the firing control disconnect cable, rotate the release fitting, and connect the cables (fig. 9-62). Release the firing control disconnect cable and rotate the release fitting until it locks. Fold the face curtain into accordian pleats and stow. Compress the handle cross bars into the detents.

WARNING: Improper installation of the face curtain or the secondary ejection control handles may result in disengagement of the cables from the control mechanism without firing the rocket catapult.

SECONDARY EJECTION CONTROL HANDLE.—Maintenance of the secondary ejection control handle parallels that of the face curtain. Since the secondary ejection control handle actuates essentially the same components as the face curtain, all the tests required of the operational check may be performed in conjunction with the face curtain check.

Attach the force gage to the center of the secondary control handle and pull straight up to disengage the handle from its detent. Force required should not be less than 5 pounds or more than 20 pounds.

Increased tension on the control handle to 25 (±5) gage pounds and check that the handle does not extend less than 1/4 inch or more than


A
CABLE END FITTINGS
RELEASE FITTING
DISCONNECT PIN
A
FIRING CONTROL DISCONNECT FITTING
GUIDE TUBE
SPRING
CABLE ASSEMBLY
DETENT BARS

AM.1205

Figure 9-62.—Face curtain and disconnect fitting—A-4F.

1 1/4 inch from the stowed position (the ejection control safety handle is in the full DOWN position).

Next, place the ejection safety control handle to the full UP position and pull the secondary control handle until the safety lockpin bottoms out in the socket. The handle should extend at least an additional 2 1/2 inches with the force applied.

Pull the disconnect firing control cable down to retract the pin in the firing control disconnect assembly. Continued pull on the secondary handle will allow the handle and cable to disengage from the seat.

While the handle and cable assembly is removed, inspect it for corrosion, kinks, broken strands, and condition of the end fittings. Installation of the handle is accomplished as follows:

Place the ejection control safety handle in the full UP position and insert the secondary ejection control handle and cable assembly through the handle recess hole in the center of the forward beam of the seat assembly. Snap the handle into the detent position.

Inspect the secondary control cable disconnect pulley housing, insuring that it is undamaged and free of corrosion and that the detents are free of cracks and burrs. Remove the secondary firing cable from the firing control disconnect assembly (if it is not already disconnected). Rotate the disconnect pulley counterclockwise as shown in figure 9-63 until a spring force is felt.

Rotate the pulley up to 90 degrees in either direction until the ball detent appears in the upper slot of the pulley housing. Insert the ball stop on lower end of the secondary ejection control cable through the slot and into the detent.

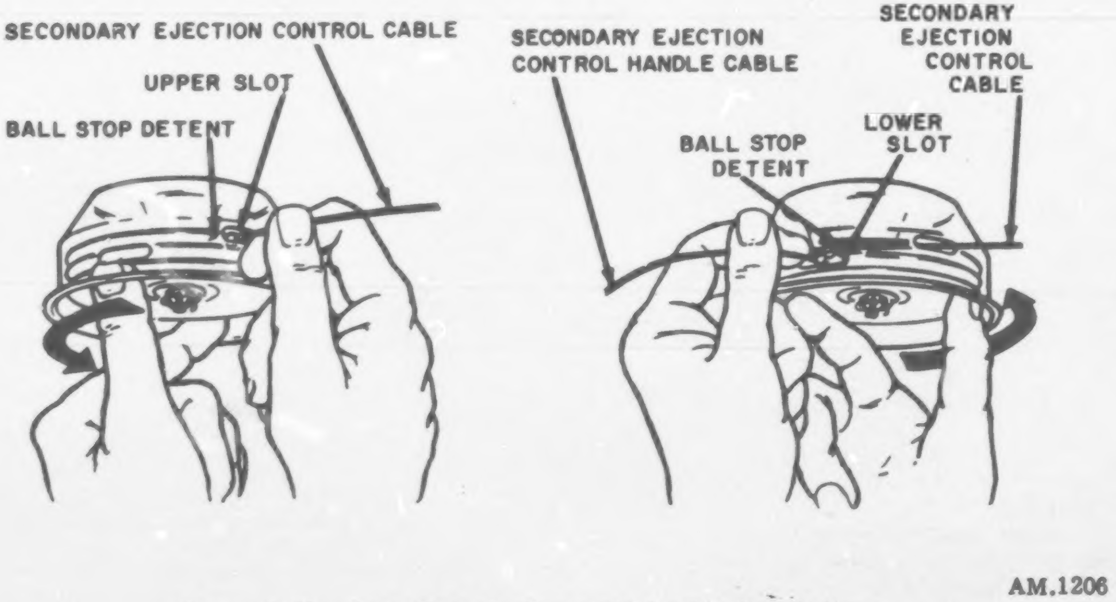
Rotate the pulley counterclockwise approximately one turn and take up the coaxial cable until the ball end detent of the lower pulley groove appears in the lower slot of the disconnect pulley housing. Insert the ball stop of the secondary ejection handle cable into the lower pulley detent.

Release the pulley and pull on the upper end of the secondary firing cable to take up any slack in the secondary ejection handle cable. Connect the secondary firing cable to the firing controls disconnect assembly at the top of the seat.

Pull the ejection control safety handle to the full DOWN position to safety the ejection control handles and prevent release of the firing cables.

SEPARATION BLADDER SYSTEM CHECK.—The separation bladders are unsnapped from the seat and checked for service life expiration date, deterioration, cracking, chafing, cleanliness, and any other casues for replacement.

The leak test is commenced by disconnecting the flexible hose from the elbow fitting on the harness release actuator and attaching it to an external source of low pressure nitrogen. The bladders are then inflated to 3 1/2 pounds, then the source of pressure is shutoff. Check for bladder leakage by observing pressure drop over a 1-minute period. Unacceptable leakage rates will require bladder replacement. If a new bladder is being installed, it must be inflated and deflated several times as prescribed in the Maintenance Instructions Manual to purge all talc from the bladder.


SECONDARY EJECTION CONTROL CABLE
UPPER SLOT
BALL STOP DETENT
SECONDARY EJECTION CONTROL HANDLE CABLE
SECONDARY EJECTION CONTROL CABLE
LOWER SLOT
BALL STOP DETENT

AM.1206

Figure 9-63.—Secondary ejection control cable installation.

When reconnecting the flex hose to the elbow of the harness release actuator, it must be properly torqued and a new torque stripe added to the connection.

When the bladder tests have been satisfactorily completed, fold the bladders in original pleats and snap the bladder covers to the seat. Reinstall the bladder protective cover to prevent damage.

EJECTION SEAT STABILIZATION SYSTEM.—During the calendar inspection, the DART stabilization and snubbing system cover must be removed to accommodate inspection of the complete stabilization and snubbing assembly.

The deployment assembly, bridle assembly, and various lanyards are inspected for fraying, broken or cut lines, any evidence of any fluid contamination, and of which would require replacement of the complete assembly. The brake assemblies (fig. 9-42) are inspected for evidence of corrosion, damage, and fluid contamination of the linings. Since the DART system is a time removal assembly, its installation date must also be checked to determine if replacement will become necessary prior to the next scheduled inspection. If so, the system must be replaced. A Quality Assurance Representative must verify proper routing of the stabilization and snubbing system lanyards prior to installation of the dart cover and the protective maintenance cover.

HARNESS RELEASE ACTUATOR CARTRIDGE INSTALLATION.—Prior to installation of the Mk 86 Mod 0 delay cartridge it must be inspected for evidence of damage and service life expiration date as explained in the coverage on cartridge removal. The correct cartridge must be used in arming the harness release actuator. The use of other similar delay cartridges, which could be physically interchangeable but with different time-delay sequence, could cause serious injury or death of the seat occupant because of improper ejection sequence.

Install the cartridge in its chamber on the harness release actuator, inserting it, case first, into the chamber. Insert the firing pin assembly into the chamber on the cartridge. Tighten the retaining nut fingertight. Align the flat surface of the retaining nut to within 5 degrees parallel to the sear sides by turning the retaining nut not more than 60 degrees of rotation. DO NOT align the nut by loosening the retaining nut from the fingertight setting. Allow Quality Assurance personnel to install the lockwire and affix a lead seal. Proper alignment is required so that the sear may be knocked free from the firing pin by the striker plate on seat ejection.

After all seat checks have been completed, the nitrogen bottle is reinstalled on the harness release actuator and lockwired as necessary and the seat is ready for installation. Following reinstallation of the seat in accordance with the Maintenance Instructions Manual, check the cockpit area and insure that all tools and equipment used in the removal, installation, and performing of maintenance have been removed.

NORTH AMERICAN LS-1 EJECTION SEAT

The North American ejection seats in the past have been mistakenly labeled as TALCO ejection seats. The name TALCO refers to the rocket used with the seat and is not the correct designation. There are several different designations of the North American ejection seat such as LW-1, LW-2, LW-3, HS-1, and the LS-1, which is discussed in this section. The letters in the designation indicate the type of ejection seat; for example, LW indicates a lightweight seat, HS indicates a highspeed seat, and LS indicates a low-speed seat. The number designation following the letters indicates the model of that seat as modified to meet the requirements for installation in a specific aircraft.

The LS-1 seat is another rocket assisted seat used for high- and low-level escape from the aircraft. Its rocket catapult operation is almost the same as that for the ESCAPAC ejection seat discussed previously. The LS-1 seat discussed in this section is the installation used in the T-2A trainer aircraft. It does not provide the pilot with a zero-zero escape capability as the ESCAPAC seat mentioned previously.

DESCRIPTION/OPERATION

When the pilot decides to eject, he may pull either the face curtain ejection handle or the D-ring handle. (The D-ring is known on some other types of seats as the auxiliary or secondary ejection control handle.) Actuation of either of these handles fires either of two pairs of ballistic initiators which discharge high-pressure gas to the ejection seat gas catapult lines, initiating the ejection sequence. The high-pressure gas performs the following functions:

Actuates a ballistic inertia reel to pull the seat occupant into an upright seated position.

Jettisons the canopy.

Actuates the ejection seat catapult cartridge.

Gas pressure to operate the inertia reel is developed by an exploding gas-generating ballistic initiator. High-pressure gas from the D-ring or face curtain initiators fires the inertia reel generator cartridge. These same gases from the D-ring or face curtain are piped at the same time to the canopy jettison system (discussed earlier in this chapter) and the rocket catapult.

A 0.4-second time delay fuze in the rocket catapult delays catapult firing for that length of time so that the ballistic inertia reel can operate and the canopy can jettison. If the canopy should fail to jettison, the seat will eject through the canopy without delay.

The ejection initiation gas lines are installed almost completely on the seat structure. Figure 9-64 illustrates these gas lines. Since the rocket catapult outer tube and the canopy actuator/remover housing (fig. 9-3) remain attached to the aircraft during ejection, a means to separate the gas plumbing is necessary. This separation is accomplished by installing quick disconnects in the system. These quick disconnects will pull loose as the seat rises on ejection.

During the upward travel of the seat the following operations are mechanically performed, in addition to separating the high-pressure gas lines quick disconnects:

The personal service composite quick disconnect is uncoupled.

The emergency oxygen bottle is actuated.

As the seat moves further up the rails, a bellcrank and linkage arrangement on the left side of the seat contacts a fixed striker pin on the seat structure (fig. 9-65). The bellcrank is rotated downward and its attached linkage pulls the sear pin from the drogue gun and arms an aneroid power device by pulling a pin from the device.

Pulling the sear actuates the drogue gun firing mechanism, and the gun fires immediately. The drogue gun projectile pulls the drogue chute out of its container, and the drogue chute deploys to stabilize the seat.

The aneroid power device actuates the harness release system in accordance with altitude. At altitudes above 13,000 feet the device prevents seat/pilot separation until descent to that altitude is achieved. Below 13,000 feet, when the anerioid arming pin is pulled, the aneroid fires the harness release time dealy instantly. This delay is 1/2 second.

The harness release mechanism provides the securing points for the pilot's integrated harness. When the release actuator fires, it forces a piston downward, contacting the bellcrank of the harness release mechanism. This actuates the release mechanism lockpins, which free the pilot's hip and shoulder straps from the seat and inertia reel.

In addition to its mechanical function, the harness release actuator directs gas pressure from its exploding cartridge to two face curtain cable cutters to free the curtain from the seat. Gas pressure is also directed to gas-actuated initiators on the seat, which fire and direct gas pressure to the seat separation bladders. This inflates the bladders, which forcibly push the pilot from the seat. Figure 9-66 is a schematic diagram of the harness release gas pressure system.

When the occupant is forcibly separated from the seat, the cable to the automatic opening device is pulled. This arms an aneroid which initiates a 3/4-second delay immediately, if ejection occurs below 10,000 feet. If ejection is above 10,000 feet the pilot free-falls, stabilized by his drogue chute, to 10,000 feet, then the time delay is initiated. When the time delay expires, the parachute opens automatically.

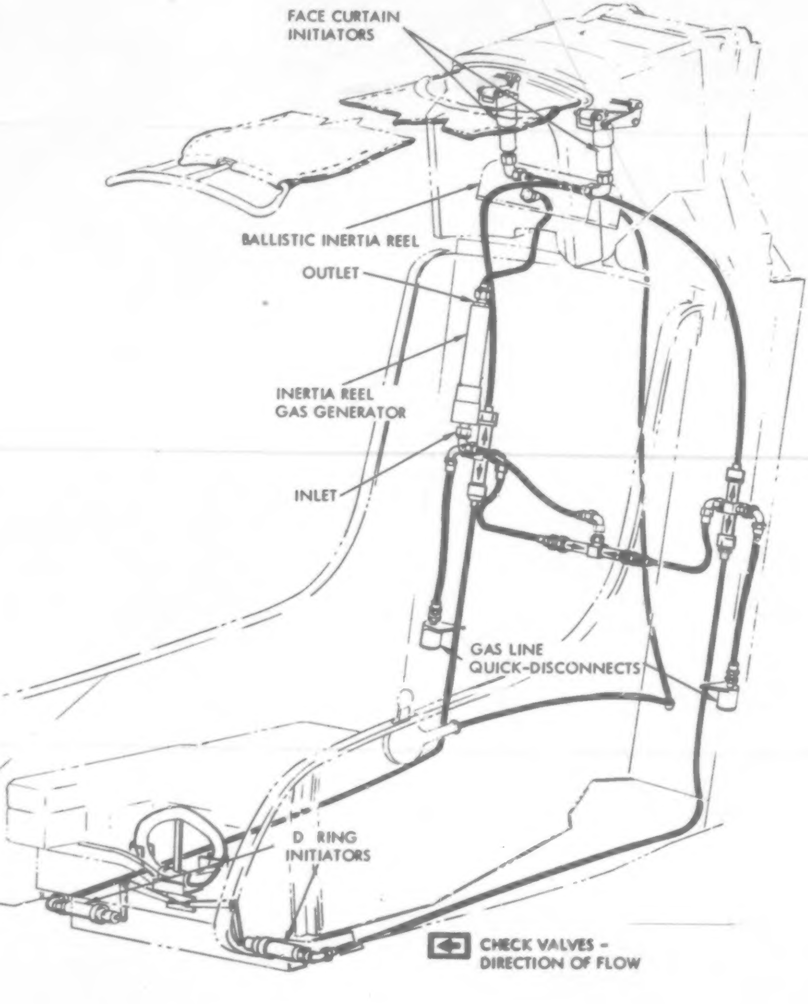
The harness release handle, located on the right-hand side of the seat, provides a means of manual operation of the harness release mechanism. The integrated harness release mechanism is illustrated in figure 9-67.

By the single action of pulling the harness release handle aft, the occupant is completely free to abandon the aircraft while retaining his integrated harness and survival equipment (including the parachute).

This feature is utilized during crash landings or bailout in the event of ejection seat failure. It allows the occupant to leave the aircraft quickly without having to unbuckle any straps.

When the pilot stands up to leave the aircraft, the cable connected to the emergency oxygen supply cylinder in the survival kit actuates the valve to supply oxygen to the pilot. The cable falls free after having actuated the oxygen supply.

During ejection, the pilot can pull the harness release handle to free himself from the seat in the event the automatic release system fails. He will be completely released from the seat with the exception of the parachute arming cable. As


FACE CURTAIN INITIATORS
BALLISTIC INERTIA REEL
OUTLET
INERTIA REEL GAS GENERATOR
INLET
GAS LINE QUICK-DISCONNECTS
D RING INITIATORS
CHECK VALVES - DIRECTION OF FLOW

AM.178

Figure 9-64.—Ejection initiation gas lines.

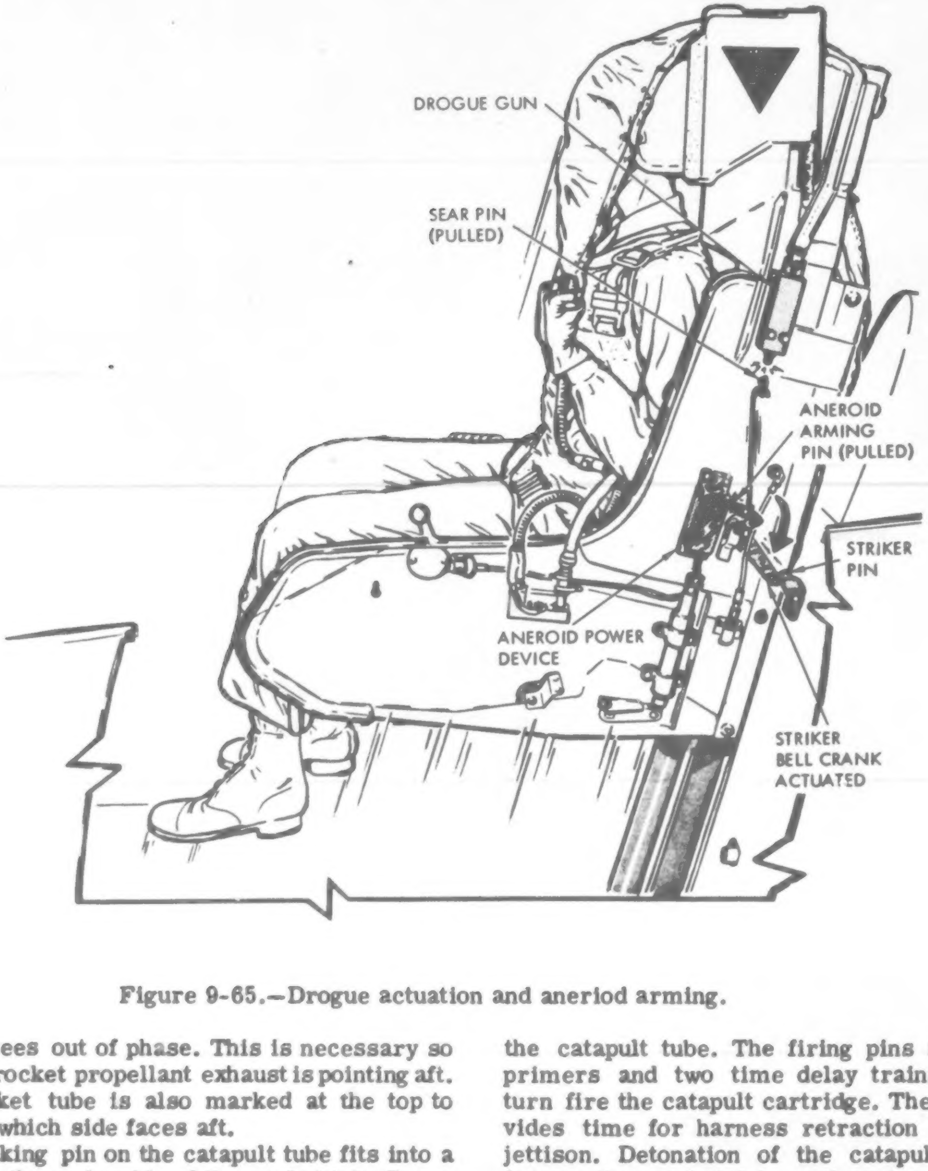
the seat and pilot separate, the arming cable is pulled, arming the parachute automatic opening device.

Catapult Rocket

The catapult rocket for the LS-1 seat includes the following major components: a catapult tube, a rocket tube, an internal catapult tube to rocket locking device, and attachments to connect the rocket to the ejection seat and the aircraft structure. Figure 9-68 illustrates the catapult rocket.

The catapult tube consists of a chamber, firing pins, and the primary cartridge. The rocket tube consists of a chamber, an igniter, the propellant, and a nozzle outlet. A trunnion fitting on the catapult tube attaches to the aircraft structure, and a trunnion fitting on the rocket tube attaches to the ejection seat headrest forging.

The rocket tube trunnion fitting is fixed and the trunnion differs between the left and right sides to prevent installation of the rocket tube



AM.179

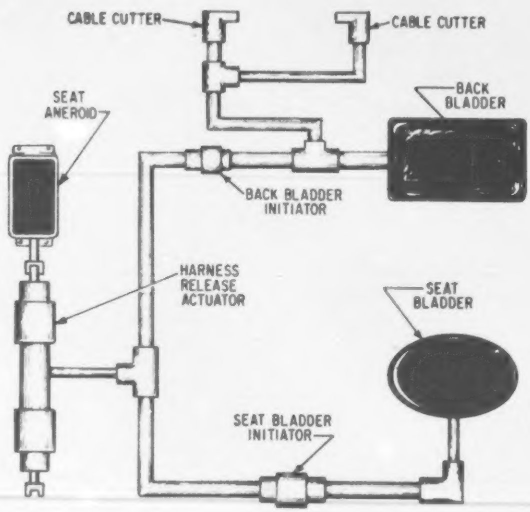
Figure 9-65.—Drogue actuation and aneriod arming.

180 degrees out of phase. This is necessary so that the rocket propellant exhaust is pointing aft. The rocket tube is also marked at the top to indicate which side faces aft.

A locking pin on the catapult tube fits into a cutout on the underside of the rocket tube flange to prevent the possibility of rotation between the two tubes. If the rocket tube lock, lockplate, or lockplate retaining screws show signs of having moved from their original position or if the lockwire is broken, the rocket must be replaced.

The catapult cartridge is fired when gas pressure from one of the initiators actuates the two firing pins located in the lower portion of the catapult tube. The firing pins actuate two primers and two time delay trains, which in turn fire the catapult cartridge. The delay provides time for harness retraction and canopy jettison. Detonation of the catapult cartridge forces the rocket tube and seat up the rails. The initial forces created on the rocket tube unlock the catapult-to-rocket-tube locking device.

As the seat nears the end of the rails, hot gases from the catapult tube ignite the solid propellant in the rocket tube. At this time the rocket tube separates from the catapult tube and continues to propel the seat upwards to the



AM. 180

Figure 9-66.—Harness release gas pressure system schematic.

altitude necessary for ground level parachute deployment.

The only maintenance authorized on the catapult rocket is removal, inspection, and installation. The rocket requires no shipping or ground safety pins. Whenever the catapult rocket is removed from the aircraft, insure that the two inlet ports on the bottom of the outer tube have dust caps installed to prevent the entrance of foreign material.

Ballistics-Operated Inertia Reel

The ballistics-operated inertia reel operates in a manner similar to those previously discussed. Operation of the manual control handle is almost always the same for the various types of inertia reels, therefore, only the power retraction is discussed in this section.

Figure 9-69 shows the manner in which ballistics gas is used to cause the power inertia reel to retract the shoulder straps. Gas is directed through high-pressure lines to the gas generator mounted on the aft side of the seat and connecting to the pressure inlet port of the inertia reel. This pressure detonates the cartridge in the gas generator and the resulting gases enter the reel mechanism and actuate the positioning mechanism to pull the pilot into an upright position. The action of the gases against the actuating piston in the reel is buffered by metering hydraulic fluid through an orifice as shown in figure 9-69.

Failure of the inertia reel to lock when the manual control handle is properly positioned can be normally corrected by adjusting the control cable inside the control handle housing in accordance with the Maintenance Instructions Manual. An inertia reel tester is available for testing the automatic locking feature and performing the proof test of the reel lock and shoulder straps without removing the reel from the seat.

Drogue Gun

The drogue gun of the LS-1 ejection seat performs the same function as the drogue gun for the Martin-Baker ejection seats. Removal of the drogue gun is only necessary when removal of the cartridge is required because of service life expiration date or some other valid reason.

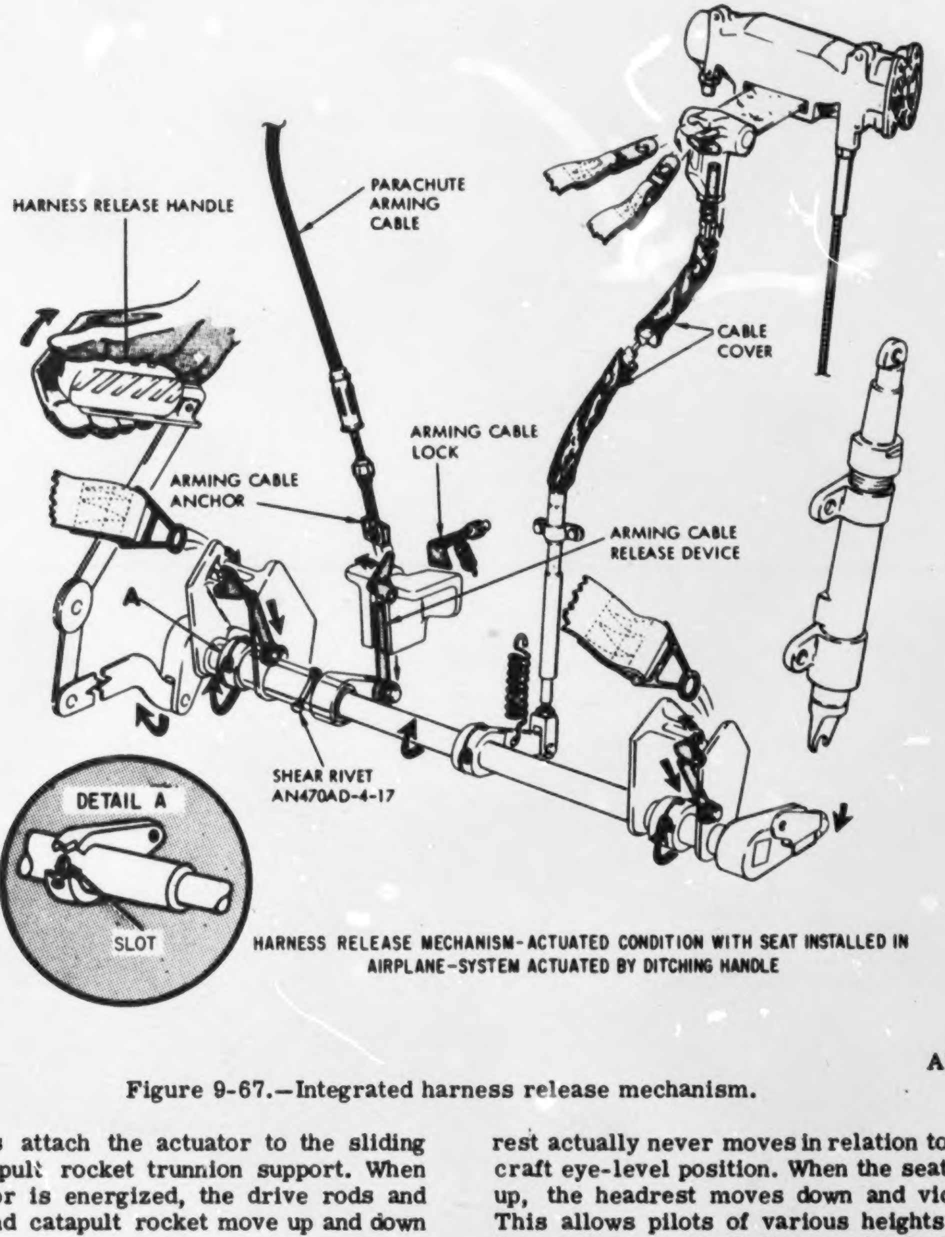
Aneroid Power Device

The aneroid power device (fig. 9-65) performs the same function as the barostat section of the time release mechanism of the Martin-Baker ejection seat. The device is equipped with a leakage indicating device that will provide the AME with a visible indication if the aneroid bellows develops a leak. If a red color is visible through the aneroid leakage indicator window at altitudes of less than 5,000 feet, the unit is faulty and must be replaced.

The aneroid power device is a sealed unit and the cover should not be removed under any circumstances. If a new device is being installed, it must be cocked. Cocking is accomplished by pulling out on the thruster rod, which connects to the harness release actuator, and inserting the arming pin into the arming pin hole. It will require considerable force to extend the thruster shaft when cocking the device, since it is highly spring loaded.

Seat Adjustment System

Like most other ejection seats the LS-1 seat in the T-2A is adjustable up and down by an electrical actuator. The actuator is mounted on the cockpit bulkhead between the seat guide rails.


HARNESS RELEASE HANDLE
PARACHUTE ARMING CABLE
CABLE COVER
ARMING CABLE LOCK
ARMING CABLE ANCHOR
ARMING CABLE RELEASE DEVICE
A
SHEAR RIVET AN470AD-4-17
DETAIL A
SLOT

HARNESS RELEASE MECHANISM-ACTUATED CONDITION WITH SEAT INSTALLED IN AIRPLANE-SYSTEM ACTUATED BY DITCHING HANDLE

AM. 1207

Figure 9-67.—Integrated harness release mechanism.

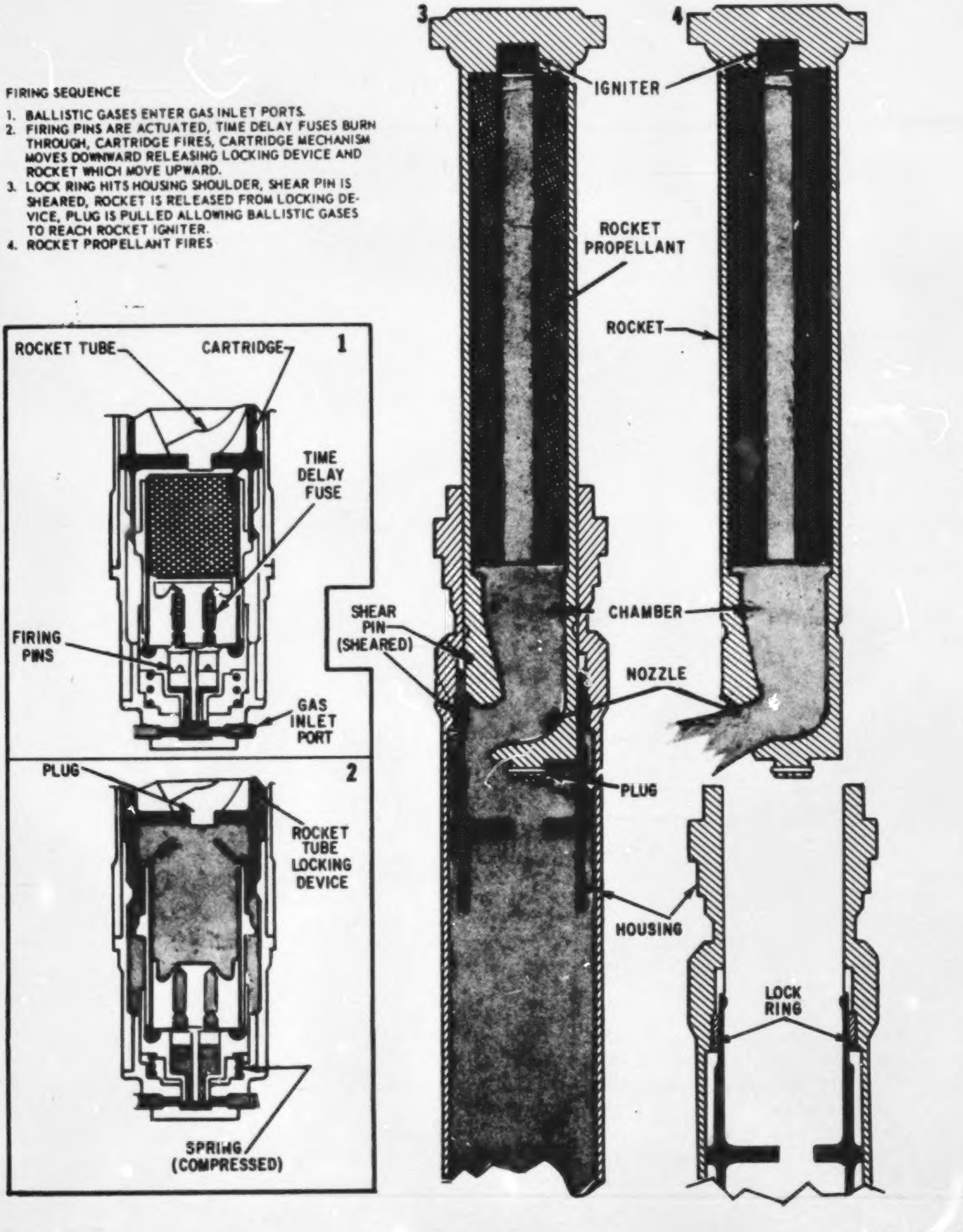
Drive rods attach the actuator to the sliding lower catapult rocket trunnion support. When the actuator is energized, the drive rods and the seat and catapult rocket move up and down as a unit.

In addition, the actuators are equipped with two power takeoff gearboxes, which are connected by torque links to the adjustable headrest jackscrews. When the seat is repositioned, the jackscrews reposition the headrest. The repositioning of the headrests in such that the headrest actually never moves in relation to the aircraft eye-level position. When the seat is moved up, the headrest moves down and vice versa. This allows pilots of various heights to adjust the seat to meet their own physical characteristics and still maintain the headrest at the optimum aircraft eye-level position.

During seat adjustment, one-half of the torque link is free to slide into the other. During ejection, the two halves simply pull apart. Detent balls in the lower halves fit into grooves in the

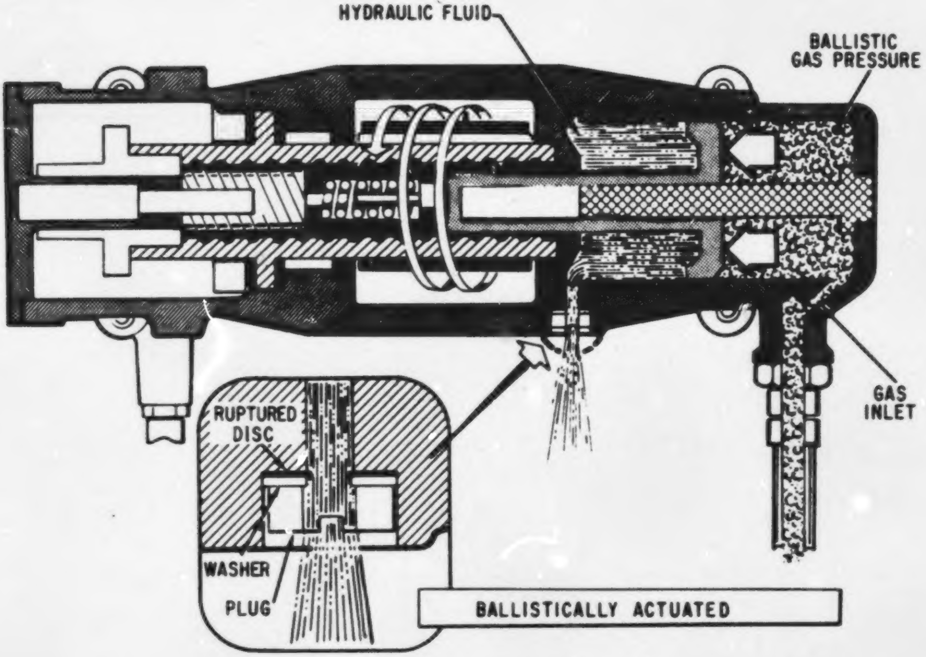
FIRING SEQUENCE

1. BALLISTIC GASES ENTER GAS INLET PORTS.
2. FIRING PINS ARE ACTUATED, TIME DELAY FUSES BURN THROUGH, CARTRIDGE FIRES, CARTRIDGE MECHANISM MOVES DOWNWARD RELEASING LOCKING DEVICE AND ROCKET WHICH MOVE UPWARD.
3. LOCK RING HITS HOUSING SHOULDER, SHEAR PIN IS SHEARED, ROCKET IS RELEASED FROM LOCKING DEVICE, PLUG IS PULLED ALLOWING BALLISTIC GASES TO REACH ROCKET IGNITER.
4. ROCKET PROPELLANT FIRES


1
ROCKET TUBE
CARTRIDGE
TIME DELAY FUSE
FIRING PINS
GAS INLET PORT
2
PLUG
ROCKET TUBE LOCKING DEVICE
SPRING (COMPRESSED)
3
4
IGNITER
ROCKET PROPELLANT
ROCKET
CHAMBER
SHEAR PIN (SHEARED)
NOZZLE
PLUG
HOUSING
LOCK RING

AM. 1208

Figure 9-68.—Catapult rocket—LS-1 ejection seat.



AM. 1209

Figure 9-69.—Ballistics inertia reel operation.

upper halves to provide a means of transmitting rotation along with the sliding feature.

MAINTENANCE

Maintenance of the LS-1 ejection seat is very limited. Seat maintenance includes the removal and replacement of cartridges and initiators because of service life expiration date or damage and the removal and replacement of faulty components discovered during the preinstallation inspection of the seat and cockpit.

There is no actual operational checkout of the escape system, since the majority of operations are initiated by gas pressure from explosive initiators and cartridges. Because of this fact, the ejection seats are subjected to a thorough preinstallation check in accordance with the applicable Maintenance Instructions Manual followed by a post installation inspection. Only qualified personnel who are thoroughly familiar with the ejection system should perform these inspections and checks.

Installation and removal of the cartridges and initiators must be accomplished with strict conformance to the procedures provided in the MIM.

SAFETY

Prior to performing maintenance on the LS-1 ejection system the AME should be thoroughly familiar with the system and any special hazards associated with the system. The emergency escape system of the T-2A is safetied with a total of nine ground safety pins. Prior to performing maintenance on the system, make sure all nine pins are installed.

When making the post installation checks the AME must exercise care not to pull or unnecessarly touch the face curtain handle, the D-ring handle, or any linkage on the left-hand side of the ejection seat.

The following list of general precautions have application to most North American ejection seats:

1. The ejection seat must be removed from the aircraft prior to removing or installing any ballistic cartridge or gas-operated device.

2. Always install the safety pin harnesses and shipping safety pins in mechanical devices before removing or installing any ballistic device.

3. Always insure that safety pin harnesses are functionally complete before installing on seat assemblies. When removing a harness from the seat, always insure that none of the pins has become disengaged from the harness and accidentally left in the seat mechanism.

4. Install shipping caps on all gas fired ballistic devices when not installed on the seat.

5. Check that proper warning decals are installed on all ballistic devices.

6. Torque all ballistic device connections to the proper torque value.

7. Torque all flexible and rigid line nuts after installation.

8. Install the proper cartridge in the proper device.

9. Install check valves and ballistic devices in the correct direction.

10. In event any component of the ejection seat is initiated, all lines, check valves, fittings, and ballistic devices that contacted the propellent gases must be replaced.

11. Be sure cartridges seat freely in their breech.

12. Check for signs of leakage or damage to cartridges or cartridge seals.

13. Check for signs of oil leakage on all ballistic devices containing buffering oil.

14. Inspect breech for foreign objects on ballistic devices which have a removal cartridge.

15. Check that firing pins are installed correctly in all ballistic devices incorporating a firing pin.

16. Only qualified personnel who are thoroughly familiar with the ejection system should be working on the system.

17. Insure that all shipping safety pins are removed from ballistic devices after installation.

CAUTION: When performing maintenance of any type on any ejection seat, the procedures and safety precautions outlined in the applicable Maintenance Instructions Manual must be strictly adhered to. DO NOT let familiarity or experience with a particular ejection system detract you from using the Maintenance Instructions Manual on every occasion where aircraft maintenance is involved.

CHAPTER 10

LINE OPERATIONS AND MAINTENANCE

Line operations and maintenance is one of the most important responsibilities of the AME3 and AME2. Line operations and maintenance is the term used to describe that work which is necessary to insure that operational aircraft, aircraft equipment, and aircraft support equipment are ready and safe for the type of flight or operations for which they are scheduled. This work is performed on a flight line, flight deck, or other place normally used to park aircraft. It is usually performed prior to or between scheduled flights, without removal of the aircraft from the flight schedule.

Line operations and maintenance includes aircraft handling, daily and preflight inspections, servicing, lubrication, jacking, and the use and maintenance of various types of aircraft support equipment. Some of these functions are not normally performed by personnel of the AME rating; however, many operating activities use third class petty officers of the AM and AD rating as Plane Captains. As a plane captain, the AME3 may be required to perform all of these functions.

AIRCRAFT HANDLING

Although aircraft handling is primarily the responsibility of the AB rating, all aircraft maintenance personnel should be familiar with proper ground handling techniques. Practically all structural damage to aircraft on the ground is caused by carelessness or lack of knowledge of proper ground handling procedures.

This section describes the duties of the taxi signalman and discusses some of the problems involved in towing, spotting, and securing aircraft.

TAXI SIGNALMAN (PLANE DIRECTOR)

Anytime an aircraft is ready to taxi from the flight line or is returning to the line for spotting, it is directed by one or more taxi signalmen as necessary.

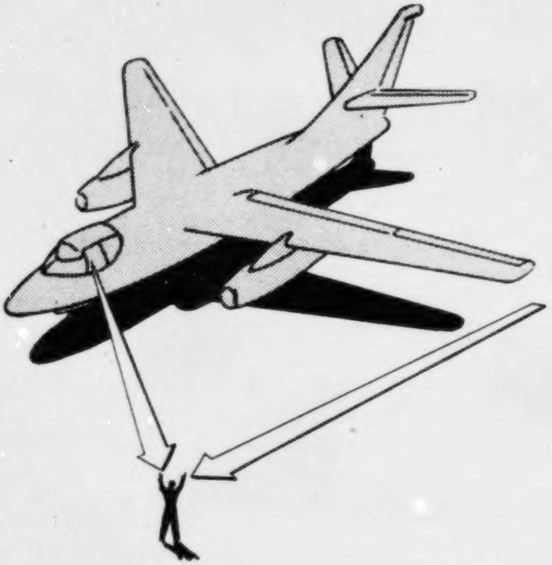
The taxi signalman should assume and maintain a position where he can see the pilot's eyes at all times. If it is necessary for him to lose sight of the pilot's eyes in changing positions, or for any other reason, he should signal the pilot to stop until he has taken up his new position.

The taxi signalman has a definite position to maintain when directing aircraft, calculated to give him all possible advantages. His position when directing single-engine aircraft should be slightly ahead of the aircraft and in line with the left wingtip. An alternate position, in line with the right wingtip, may be used when it is necessary to clear obstructions.

When directing aircraft with side-by-side seating, such as is found on multiengine aircraft, his position is forward of the left wingtip. He has no alternate position since the pilot of a multiengine aircraft sits on the left-hand side of the cockpit. When directing multiengine aircraft in obstructed areas, an assistant taxi signalman may be used on the right wingtip. The assistant taxi signalman will signal the aircraft taxi signalman on the left wingtip. The taxi signalman must always be in a position to see the assistant taxi signalman and the pilot's eyes. Figure 10-1 illustrates the taxi signalman's position directing aircraft.

When towing aircraft, the same positions are used as for directing an aircraft moving under its own power. The taxi signalman must keep the occupant of the cockpit (usually the plane captain), the driver of the towing vehicle, and assistant taxi signalmen in sight at all times.

Aircraft being taxied on land within 25 feet of obstructions must have a taxi signalman at each wingtip. If an obstruction is present on one side only, a man at that wingtip is required. Aircraft must not be taxied at any time within 5 feet of obstructions. Aircraft being taxied on water must not be taxied closer than 50 feet to obstructions except in mooring or docking



AM. 190

Figure 10-1.—Position of taxi signalman.

procedures or when dictated by nature of the mission. Extra precaution is necessary when directing aircraft at night. The taxi strip and parking area should be inspected for workstands and any other mobile equipment which can damage an aircraft.

Standard Taxi Signals

Standard taxi signals are used by all branches of the Armed Forces so that there will be no misunderstanding when a taxi signalman of one service is signaling a pilot from another. These signals are for the most part given with the hands; at night plastic wands attached to regular flashlights are used. The signals should be definite and precise to eliminate any possible misunderstanding and to inspire the pilot's confidence in the taxi signalman.

The Airman Manual, NavPers 10307-C, chapter 12, lists and explains the standard taxi signals used by all branches of the Armed Forces for the operation and movement of aircraft on the ground, including helicopter landing, takeoff, and ground handling signals.

Aircraft handling procedures and signals peculiar to shipboard operations which would be of interest to plane captains and other maintenance personnel assigned to the flight deck are listed in the CVA/CVS NATOPS Manual. A similar manual is provided for the use of personnel assigned to Amphibious Assault Ships (LPH).

The General Information section of each aircraft Maintenance Instructions Manual lists the necessary special signals which are required for that specific aircraft and are not covered by the standard taxi signals.

TOWING AIRCRAFT

Towing aircraft can be a hazardous operation, causing damage to the aircraft and injury to personnel, if done recklessly or carelessly. The following paragraphs outline the general procedure for towing aircraft; however, specific instructions for each model of aircraft are detailed in the General Information section of the applicable Maintenance Instructions Manual and should be followed in all instances.

NOTE: Most naval aviation activities issue specific instructions concerning aircraft towing. These instructions usually contain the composition of the tow crew, tow tractor speed, and various other instructions concerning local conditions. These instructions must be complied with.

Aircraft are generally moved (towed) by a tow crew. The tow crew is usually composed of a tractor driver, a plane captain (to man the cockpit), and one man to watch for clearance at each wingtip and the tail.

The man assigned to operate the brakes must be thoroughly familiar with the particular type aircraft. His main function is to operate the brakes in case the tow bar should fail or come unhooked. He must also be familiar with the operation of various systems such as the ejection seat, power canopy, wing fold, and the safety precautions associated with each.

The men assigned to observe the wings and tail should proceed at their assigned stations as the aircraft is being towed. It is the responsibility of these men to keep a sharp lookout for obstructions and signal the tractor driver in time to prevent collisions. Signals may be given with the hands or a whistle.

Only qualified personnel should attempt to tow an aircraft. Driving a tow tractor requires specialized training as well as a valid Navy drivers's license.

Tow Bars

There are two types of tow bars—universal and special. Special tow bars are those designed for use with only one type of aircraft. The universal tow bar is designed to tow a number of different types of naval aircraft.

The universal tow bar (NT-4) which is now being used by the Navy is shown in figure 10-2. This tow bar is designed with sufficient tensile strength to pull most aircraft, but is not intended to be subjected to torsional or twisting loads. Although the universal tow bar has small wheels that permit it to be towed behind the tow tractor when going to and from an aircraft, it will suffer less damage if it is loaded aboard the tow tractor and hauled to the aircraft. When the bar is attached to the aircraft, all engaging devices should be inspected for damage or malfunctions before moving the aircraft.

The universal tow bar, when used for nosewheel towing (fig. 10-3) is secured to the nosewheel axle by means of two pins and a tensioning chain and knob.

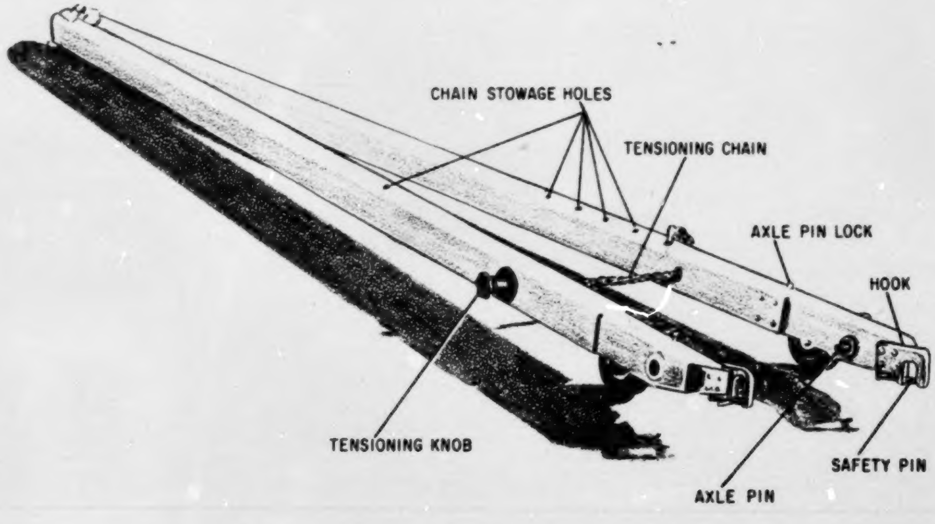
To mount the universal tow bar on a nosewheel, the tensioning knob is loosened and the chain is released. After the bars are lifted and the pins inserted into the axle ends, the chain is drawn tightly through the bar and hooked in the slot which is provided to lock it in place. Tightening the tensioning knob then applies enough pressure to hold the bar pins in the ends of the axles.

Holes are provided in one bar to stow the pin on the loose end of the tensioning chain. Placing this pin in one of these stowage holes eliminates the possibility of damaging the chain by dragging it on the deck as the aircraft is being towed.

The universal tow bar may be used to tow aircraft from rings mounted on the fuselage or landing gear. The tow bar is secured to these rings by means of hooks which are mounted on the ends of the bars. A spring-loaded safety pin secures the hooks in the rings.

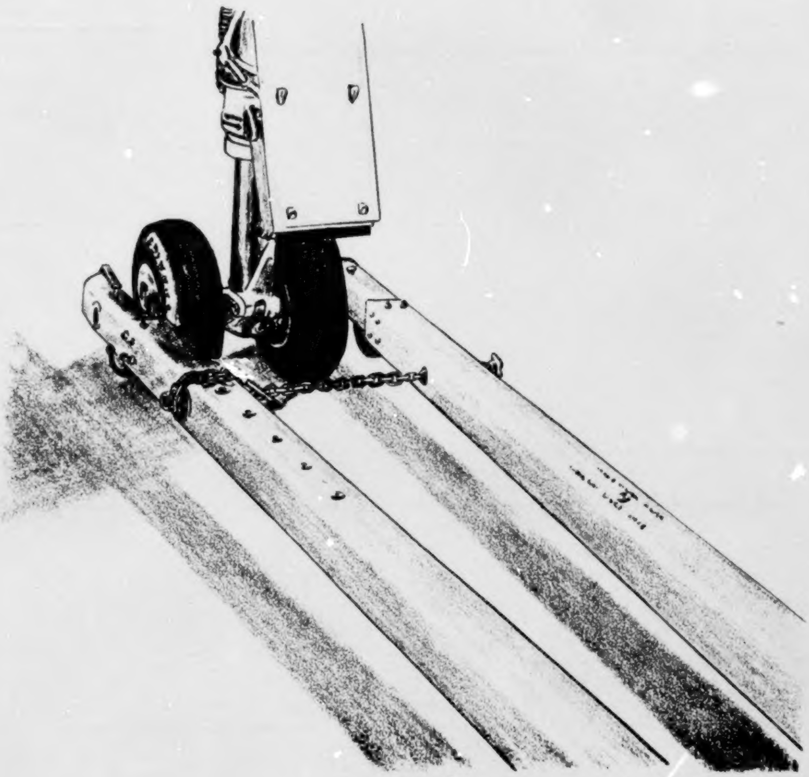
Special tow bars are designed to be secured to the aircraft in various ways. The information contained in the applicable Maintenance Instructions Manual should always be followed when attaching special tow bars to an aircraft.

When towing the aircraft, the towing vehicle speed must be reasonable, and all persons involved in the operation must be alert. Only reliable, competent personnel should be assigned to operate tow tractors. When the aircraft is spotted, the brakes of the tow tractor should not be relied upon to stop the aircraft. The man in the cockpit should be alert for the possible need of aircraft brakes along with those of the tow tractor.



AM. 193

Figure 10-2.—Universal tow bar (NT-4).



AM.194

Figure 10-3.—NT-4 tow bar attached to nosewheel.

NOTE: Before towing an aircraft, insure that all landing gear ground safety locks are installed. Landing gear ground safety locks are pins and clamps which are used to insure that the landing gear does not retract accidentally while ground handling the aircraft.

SPOTTING AIRCRAFT

An aircraft can be spotted on the flight line under its own power, by the use of a tow tractor, or manually by pushing. If it is spotted manually, the handling crew should be instructed not to push on any control surfaces or other areas on the aircraft which are stenciled "no push," as damage to the aircraft may result. Regardless of the method used to spot the aircraft, a qualified man must be in the cockpit to operate the brakes.

A qualified signalman should also be used to direct the aircraft to its assigned spot. Sometimes the spots will be painted on the parking ramp, but in many cases he will have to be familiar with the parking area so he can spot the aircraft in the best position for securing it to the tiedown pad eyes. The position of the taxi signalman during spotting is the same as for taxiing, and he should be able to see the eyes of the man in the cockpit at all times.

When spotting aircraft at night, extra precautions should be taken to insure that the parking area is clear of all workstands and other equipment. Assistant taxi signalmen should be used at each wingtip to insure that the path is clear and that there is no danger of hitting other aircraft or obstructions.

When the aircraft is spotted in its proper position, the brakes should be applied and held until the main landing gear wheels are chocked.

AIRCRAFT TIEDOWN

The tiedown of aircraft is a very important part of ground handling. When tying down aircraft, the expected weather conditions will determine how the aircraft should be secured. The tiedown procedures provided in the General Information and Servicing volume of the applicable Maintenance Instructions Manual include normal weather tiedown procedures and heavy or severe weather tiedown procedures. Some MIM's also include special tiedown procedures to be used when jacking an aircraft aboard ship while the ship is underway. Figure 10-4 illustrates the severe weather and shipboard tiedown arrangement for the A-6A aricraft. One tiedown per fitting is designated as sufficient for normal weather tiedown.

Carrier Aircraft Based Aboard Ship

Aircraft aboard carriers are tied to pad eyes which are welded into the flight deck and the hangar deck. These pad eyes are quite similar to the pad eyes found embedded in the concrete parking areas of naval air stations.

The tiedown of aircraft aboard aircraft carriers is practically the same as that specified for aircraft based ashore. However, since the carrier is subject to movement, the aircraft must be tied down securely as soon as it is parked. Most carriers require the use of at least three tiedowns as soon as it is parked and more if it is to be left unattended. The total number of tiedowns necessary depends upon the operating conditions. The General Information section of the aircraft Maintenance Instructions Manual contains information concerning tiedown points, type tiedowns to be used and the number of tiedowns to be used on each aircraft. The Air Department of the carrier may have additional instructions which may require more tiedowns than specified in the applicable Maintenance Instructions Manual.

The tiedown commonly used aboard carriers is illustrated in figure 10-5. The chain type tiedown (TD-1) is used to secure aircraft aboard ship and ashore. It has a rated capacity of 10,000 pounds. Each TD-1 tiedown weighs about 12 pounds.

The TD-1 tiedown consists of a chain and a tensioning device. The chain is inserted into the tensioning device and locked by a spring-loaded lock. After the chain is locked in the tensioning device the tiedown may be tightened by turning the tension nut in the direction of the arrow on the end of the nut. The TD-1 tiedown is released by pulling the release lever up and back.

Land and Carrier Aircraft Based Ashore

Aircraft ashore on naval air stations are tied down on concrete parking areas equipped with ringlike fittings called pad eyes. These pads eyes are installed when the concrete is poured and are installed flush with the surfaces of the concrete. The aircraft to be tied down is spotted in the parking area in the best position for full utilization of the pad eyes. If high winds are anticipated, they should be headed into the wind. The aircraft may be tied down with chain type tiedowns or manila line.

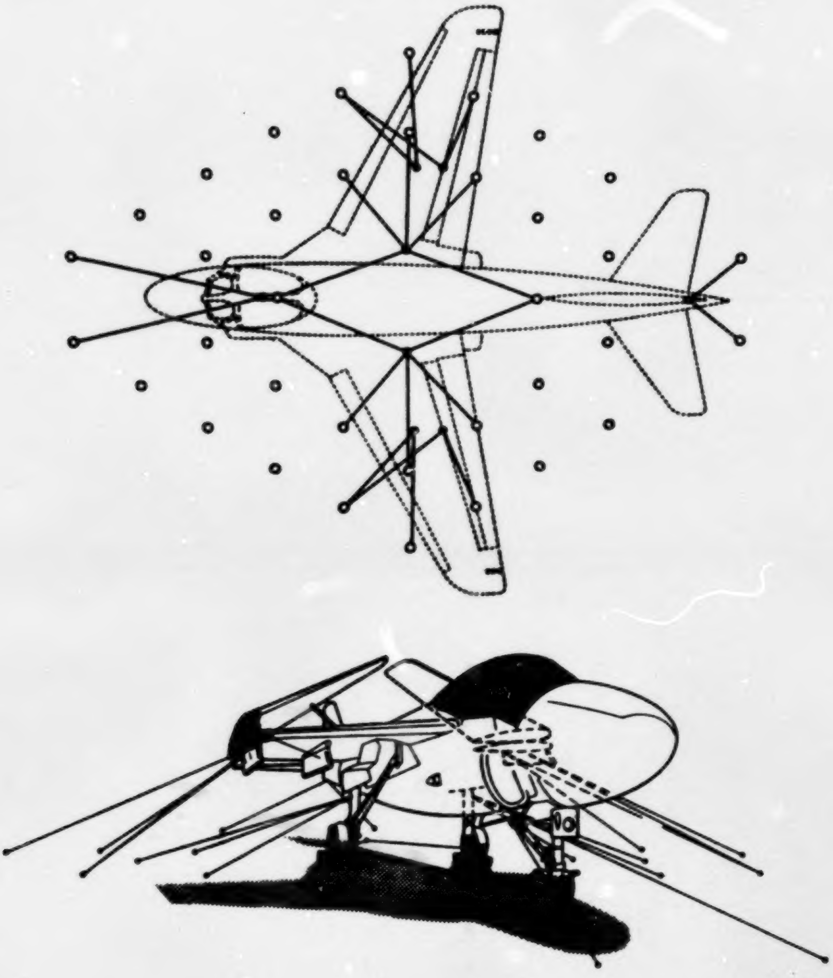
When manila line is used, it should be whipped at one end and have an eye splice at the other. Put one end through the tiedown ring or point on the aircraft and the other end through the pad eye, thread the whipped end through the eye splice and tighten up on the line. Then secure the line, using half hitches or a rolling hitch together with half hitches.

CAUTION: When manila line is used, it should be carefully adjusted to provide for shrinkage due to moisture. However, excessive line slack which would allow shifting of the aircraft should be avoided.

The number of tiedown lines or chains to use when securing the aircraft is governed by the anticipated weather conditions. The normal and heavy weather tiedown procedures are given for each type aircraft in the applicable Maintenance Instructions Manual.

Most aircraft are equipped with surface control locks which should be engaged or installed whenever the aircraft is secured. Some aircraft control surfaces are locked by simply moving a lever and aligning the controls in the neutral position. However, some aircraft require the use of gust locks such as the one shown in figure 10-6. Since the method of locking controls will vary on different type aircraft, check the applicable Maintenance Instructions Manual for the proper installation or engaging procedure.

When extremely high winds are anticipated and the aircraft cannot be moved into the hangar,



AM. 1210

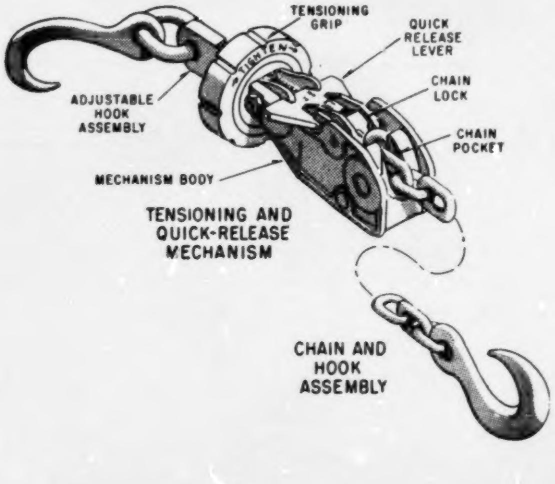
Figure 10-4.—Tiedown arrangement—A-6A.

the aircraft should be turned so that it faces into the wind. All covers and guards which protect the canopy, wing butts, air intakes, and other parts of the aircraft should be installed. These protective covers should also be installed if the aircraft is to remain secured on the line for any length of time.

A special heavy-duty tiedown (fig. 10-7) commonly referred to as a full power chain assembly is used to secure the aircraft to the deck while the engine is being run up to full power for check and adjustments.

The full power tiedown assembly consists of a coupler, chain and a deck fitting. The coupler adapts to the catapult holdback fitting on the aircraft. The chain is made of welded links and is attached to the coupler and deck fitting with removable shackles. The deck fitting assembly permits 360 degrees horizontal travel around the deck and 0 to 45 degrees vertical angle from the deck. The deck fitting assembly adapts to the various types of pad eyes.

Only specifically tested and designated pad eyes should be utilized for high power turnups.



AM. 198

Figure 10-5.- Chain type tiedown—TD-1.

In other words, all pad eyes that will accommodate the full power chain assembly should not be considered strong enough to withstand the stress of a full power turnup.

When carrier aircraft are tied down with their wings folded, a jury strut which gives extra support to the folded part of the wing must be installed. When aircraft must be left on the flight deck of a carrier in extremely heavy weather (winds in excess of 100 knots), the wings should be left in the spread position.

Aircraft are spotted and tied down aboard the carrier with just inches between each aircraft. Therefore, it is of utmost importance that they be secured properly to prevent any excessive movement when the ship is maneuvering or encountering heavy seas. Excessive movement of just one aircraft may cause serious damage to several aircraft.

USE OF COVERS AND SHROUDS

Protective covers and shrouds are provided by the aircraft manufacturer for each aircraft. These covers are designed to protect various areas and components of the aircraft from the elements, to protect personnel, and to prevent foreign objects from entering vital areas during periods of extended inactivity. The applicable Maintenance Instructions Manual contains information concerning the installation of covers and protective devices. Protective covers are usually provided for canopies, engine air intakes and exhausts, wing and vertical stabilizer fold areas, and various other ducts or inlets.

Protective covers should be tightly installed. All straps and locking devices should be secured. Loose ends should not be left to blow in the wind. The loose end of a strap, particularly one with a metal clip or buckle, will severely damage the finish of an aircraft.

Care should be taken when handling protective covers to insure that grit or trash does not collect on the inner liner. The installation of a dirty cover may scratch the finish of the aircraft or severely damage transparent plastic canopies and glass windshields.

All protective covers should be installed in such a manner that free drainage is assured. Care should be taken not to create an area which will trap and hold salt water. Covers may also act as a greenhouse in warm weather and cause collection and condensation of moisture underneath. Covers should be loosened or removed and the aircraft ventilated on warm sunny days.

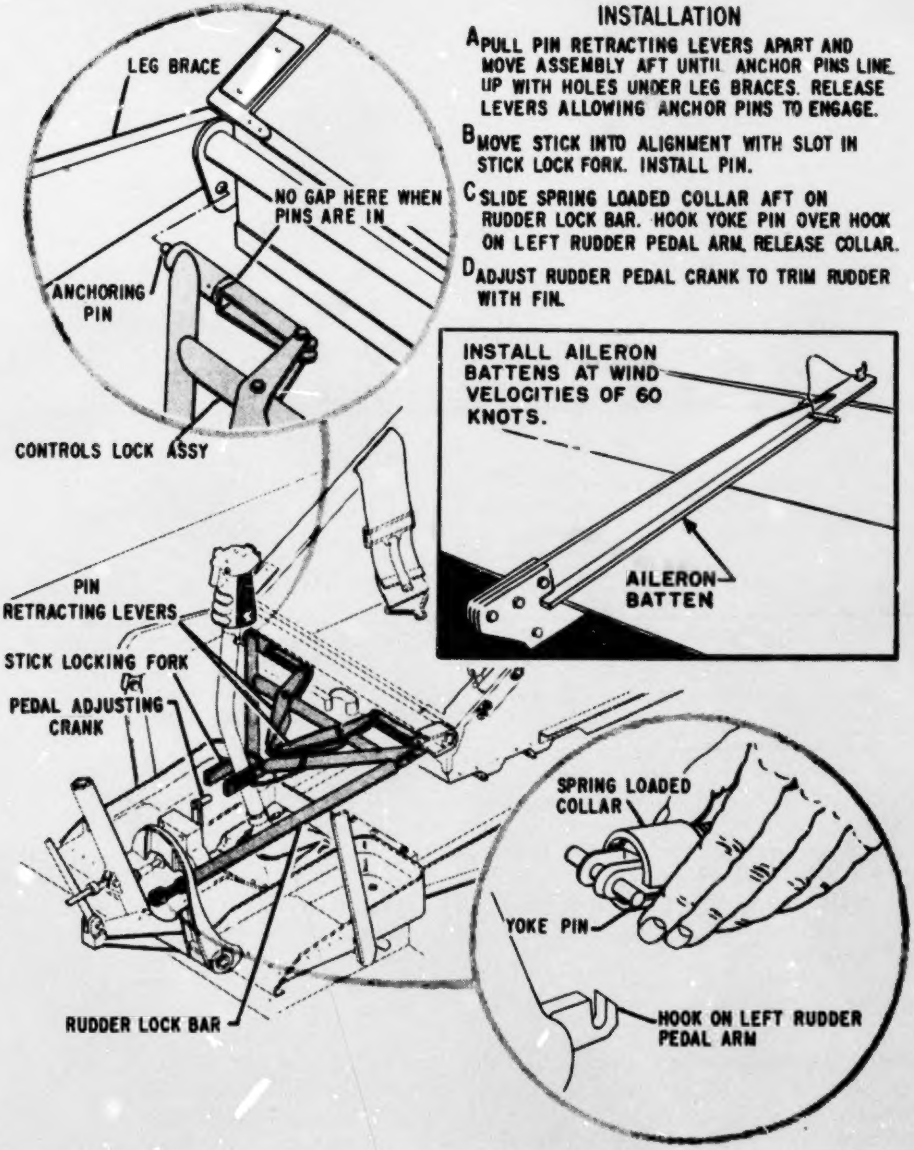
FLIGHT LINE SAFETY PRECAUTIONS

In addition to the more specific safety precautions presented in various other chapters and in other sections of this chapter, there are a number of miscellaneous precautions which must be observed when working on the aircraft flight line. The following are especially important.

Intake Duct Hazards

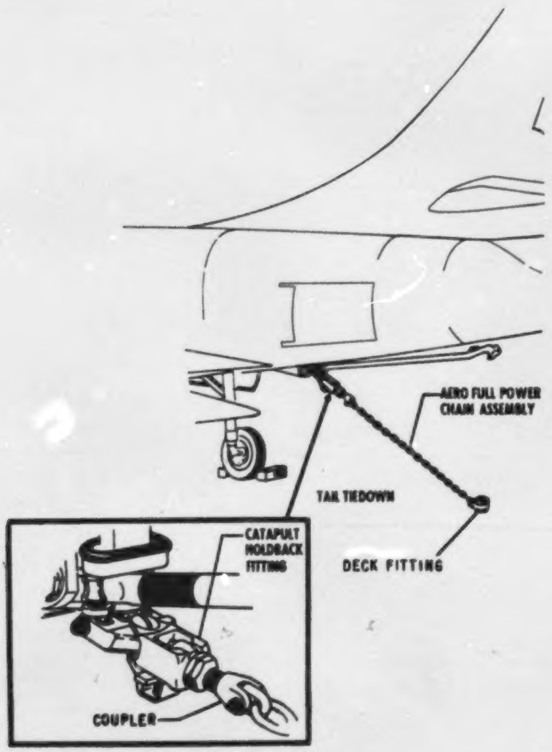
When working with reciprocating engine aircraft, the propeller represents the greatest single hazard to personal safety; however, the jet engine presents several major hazards. The air intake duct of operating jet engines represents an ever-present hazard to both personnel working near the inlet duct of the aircraft and to the engine itself if the turnup area around the front of the aircraft is not kept clear of debris. This hazard is, of course, greatest during maximum power settings.

The air inlet duct may develop enough suction to pull hats, eyeglasses, loose clothing, and rags from pockets. All loose articles should be made secure or removed before working around the engine. In some engines the suction is strong


INSTALLATION
A PULL PIN RETRACTING LEVERS APART AND MOVE ASSEMBLY AFT UNTIL ANCHOR PINS LINE UP WITH HOLES UNDER LEG BRACES. RELEASE LEVERS ALLOWING ANCHOR PINS TO ENGAGE.
B MOVE STICK INTO ALIGNMENT WITH SLOT IN STICK LOCK FORK. INSTALL PIN.
C SLIDE SPRING LOADED COLLAR AFT ON RUDDER LOCK BAR. HOOK YOKE PIN OVER HOOK ON LEFT RUDDER PEDAL ARM. RELEASE COLLAR.
D ADJUST RUDDER PEDAL CRANK TO TRIM RUDDER WITH FIN.
LEG BRACE
NO GAP HERE WHEN PINS ARE IN
ANCHORING PIN
CONTROLS LOCK ASSY
INSTALL AILERON BATTENS AT WIND VELOCITIES OF 60 KNOTS.
AILERON BATTEN
PIN RETRACTING LEVERS
STICK LOCKING FORK
PEDAL ADJUSTING CRANK
SPRING LOADED COLLAR
YOKE PIN
HOOK ON LEFT RUDDER PEDAL ARM
RUDDER LOCK BAR

AM. 197

Figure 10-6.—Surface control locking device and batten installed.



AM.199
Figure 10-7.—Full power tiedown.

enough to pull a man up to, or partially into, the inlet. Needless to say, precautions must be taken to keep clear of the inlet.

Protective screens are supplied as part of the ground handling equipment for most jet aircraft. These screens should be installed prior to all maintenance turnups.

Exhaust Area Hazards

Jet engine exhaust creates several hazards. Tests show that the carbon monoxide content of jet exhaust is low; however, other gases are present which are irritating to the eyes. Less noticeable, but important, is the respiratory irritation which may be caused.

The two most important hazards of jet engine exhaust are the high temperature and high velocity of the exhaust gases from the tailpipe. High temperatures will be found up to several hundred feet from the tailpipe, depending on wind conditions. Closer to the aircraft, these temperatures are high enough to deteriorate bituminous pavement.

Quite frequently when a jet engine is being started, excess fuel accumulates in the tailpipe; when the fuel ignites, long flames are blown out of the tailpipe. The possibilities of this hazard should be known by flight line personnel and all flammable materials should be kept clear of the danger area.

During maximum power settings, the high velocity of the exhaust gases may pick up and blow loose dirt, sizable rocks, sand, and debris several hundred feet. Therefore, due caution should be used in parking an aircraft for runup. The General Information section of the applicable Maintenance Instructions Manual contains information concerning the exhaust area hazards. These instructions should be strictly adhered to. NO ONE should foolishly experiment with the safety margins specified.

After engine operation, no work should be done to the exhaust section for at least one-half hour (preferably longer). If work is necessary immediately, asbestos gloves must be worn.

Engine Noise

Modern jet engines produce noise capable of causing temporary as well as permanent loss of high frequency hearing. The proper precautions are as follows:

1. Wear the proper ear protection (earplugs and/or sound attenuators).
2. Do not exceed the time limits on exposure to the various sound intensities.
3. Have periodic checks on hearing ability.

Engine noise is broadcast from the aircraft in patterns which vary in direction, distance, and intensity with engine speed. Generally, the most intense sound areas are in the shape of two lobes extending out and aft from the aircraft centerline. However, dangerous intensities are also present to the side and forward of the aircraft.

Damage to hearing occurs when the ear is exposed to high sound intensities for excessive periods. The higher the sound intensities, the shorter is the period of exposure which will produce damage. Above 140 db sound intensity, any exposure without ear protection can cause damage.

NOTE: Sound intensity is measured in decibels (db). A decibel is a number which relates a given sound intensity to the smallest intensity that the average person can hear.

The wearing of regulation earplugs or sound attenuators will raise the limits of time exposure. All personnel working within danger areas should be familiar with calculated db levels (as specified in the applicable Maintenance Instructions Manual) and should wear the necessary protective equipment.

Movable Surface Hazards

Movable surfaces such as flight control surfaces, speed brakes, power operated canopies, and landing gear doors constitute a major hazard to flight line personnel. These units are normally operated during ground operations and maintenance. Therefore, care should be taken to insure that all personnel and equipment are clear of the area before operating any movable surface.

Power operated canopies have safety locks which must be installed during ground handling operations. These safety locks prevent the accidental closing of the canopy and this eliminates the possibility of personnel being crushed as the canopy closes.

The General Information and Servicing section of each Maintenance Instructions Manual contains specific information concerning the various movable surface hazards and specifies the safety locks which must be used. Personnel involved with line operations and maintenance should pay particular attention to this information since some of these units move extremely fast and with terrific power.

Seat Ejection Mechanisms

All safety precautions must be strictly observed when working around aircraft equipped with an ejection seat. These safety precautions cannot be overemphasized, as accidental actuation of the firing mechanism can result in death or serious injury to anyone in the cockpit area.

Each ejection seat has several ground safety pins, the exact number depending upon the type of seat. These safety pins are provided on redflagged lanyards for use at every point of potential danger. They must be installed whenever the aircraft is on the ground or deck, and must never be removed until the aircraft is ready for flight.

The following general precautions should always be kept in mind:

1. Ejection seats must be treated with the same respect as a loaded gun.
2. Always consider an ejection seat system loaded and armed.
3. Before entering a cockpit, know where the ejection seat safety pins are and be certain of their installation.
4. Only authorized personnel may work on ejection seats and components and only in an authorized area.

Overheated Wheel Brakes

In the event an aircraft has been subjected to excessive braking, the wheels may be heated to the point where there is danger of a blowout or fire. NOTE: Excessive brake heating weakens tire and wheel structure, increases tire pressure, and creates the possibility of fire in the magnesium wheel. When the brakes on an aircraft have been used excessively, the fire department should be notified immediately and all unnecessary personnel should be advised to leave the immediate area.

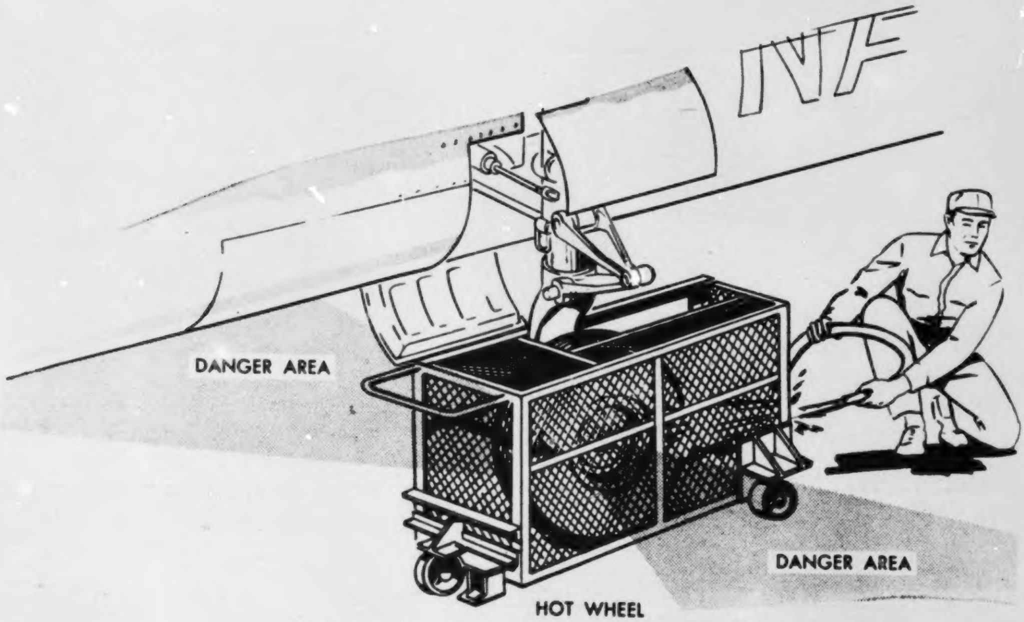
If blowout screens such as the one shown in figure 10-8 are available, they should be placed around both main wheels. These screens help to eliminate the possibility of damage or injury in the event of a blowout. If the tire is flat, explosive failure of the wheel or tire will not result. However, upon sudden cooling, an overheated wheel may fracture or fly apart, which could hurl bolts or fragments through the air with sufficient speed to injure personnel.

Required personnel should approach overheated wheels with extreme caution in the fore or aft directions—never in line with the axle.

NOTE: The area on both sides of the tire and wheel, in line with the axle, is where the fragments would be hurled if the tire were to explode and is therefore called the danger area (fig. 10-8).

Heat transfer to the wheel will continue for some period of time until the brake is cooled. Therefore, the danger of explosive failure may exist after the aircraft is secured if action is not taken to cool the overheated brake.

The recommended procedure for cooling overheated wheel, brake, and tire assemblies is to park the aircraft in an isolated location. Then allow the assembly to cool in ambient air for a period of 45 to 60 minutes. The use of cooling agents to accelerate cooling is not



AM. 200

Figure 10-8.—Blowout screen for overheated brakes.

recommended unless operational necessity dictates their use. The application of the agents exposes personnel to danger by requiring their presence near the overheated assembly. However, if it is necessary to accelerate cooling, water or fog is recommended.

When using water, direct a stream to the brake. The water should be applied in 10- to 15-second periodic bursts, not in a continuous discharge. Each application should be separated by a wait period of at least 30 to 60 seconds. A minimum of 3 to 5 applications is usually necessary. If water is not available, use any other nonflammable liquid available. Never use CO_2 for cooling.

When fog is used, the fog is deflected to the brake side of the wheel for a period of 5 to 10 seconds. Each application should be separated by a waiting period of at least 20 seconds. This method is applied as long as it is necessary to control the temperature of the affected assembly.

Once the brake has been properly cooled, permit the wheel to cool in ambient air. A crosswind or forced air from a blower or fan will assist in cooling the wheel.

The aircraft should not be moved for at least 15 minutes following cooling operations.

FLIGHT DECK SAFETY PRECAUTIONS

The flight deck of an aircraft carrier is one of the most hazardous places in the world and one of the busiest during launching, recovery, and respotting of aircraft. Plane captains and other maintenance personnel assigned specific duties associated with the flight deck must be constantly aware of this dangerous environment.

The predeployment training lectures for such personnel should include shipboard handling procedures, flight and hangar deck safety precautions, responsibilities during launch and recovery of aircraft, tiedown requirements and techniques, and special shipboard maintenance procedures and safety precautions. This training requirement is in addition to the general indoctrination given all personnel concerning flight quarters, general quarters, fire, abandon ship, man overboard, and other general drills; ship conditions, smoking and safety precautions and watch standing requirements peculiar to shipboard operations.

The previously discussed flight line safety precautions are applicable to flight deck operations. The primary difference is that because of the limited space and tempo of operations experienced on the flight deck the situation is increasingly more dangerous.

During launching and recovery of aircraft all personnel not required by such operations should leave the flight deck and catwalk areas. The safe parking area aft of the island is an unauthorized space for personnel during aircraft recovery.

Personnel should not stand in or otherwise block entrances to the island structure or exits leading off the catwalks. Never turn your back on aircraft taxiing on the flight deck. Be alert for the unexpected at all times. There is no room for carelessness, daydreaming, or skylarking on the flight deck at any time.

All personnel assigned flight quarters on or above the hangar deck must wear appropriate jerseys and helmets. Personnel on the flight deck during flight quarters must wear the cranial impact helmet or its equivalent, goggles, sound attenuators, flight deck shoes, flotation gear, and an adequately secured whistle and survival light.

Any maintenance performed on aircraft which will require wingspread/fold, respot, turnup, blade track, jacking, etc., or maintenance that will prevent the aircraft from being moved regardless of how much or how little time is required for the work to be performed must take into consideration the fact that approval to proceed with such maintenance actions must be approved through the activity's Maintenance Control. The activity's Maintenance Control, before it can grant approval, must have obtained permission from the Aircraft Handling Officer via the Air Wing/Group Maintenance Liaison Officer or his representative.

When participating in aircraft turnup or jacking operations make sure that the permission of the Aircraft Handling Officer has been received as previously stated and that all ship's regulations are observed. Safety men with sufficient line to block off the area must be stationed around the aircraft.

Each ship may have safety precautions unique to that ship due to special circumstances and operational requirements. Petty officers are charged with the responsibility of knowing and enforcing those that apply to their area of work and their men.

ARMED AIRCRAFT PRECAUTIONS

Maintenance personnel must remain alert to the potential danger of the weapons utilized on the various types of aircraft. Shore stations utilize a specified area for arming and dearming aircraft. Aircraft returning from flights with hung weapons are required to be dearmed (by qualified Aviation Ordnancemen) in the landing area or just clear of the landing area. If forward firing weapons are involved the aircraft must be stopped with a clear area ahead of the aircraft and dearmed prior to taxiing into designated recovery spots. All aircraft landing with unexpended weapons should be dearmed as soon as possible and in ALL cases prior to commencement of any postflight checks, servicing, or refueling of the aircraft.

PREVENTION OF FOREIGN OBJECT DAMAGE TO JET ENGINES

Foreign object damage is an ever-present hazard to the operation of jet engines. It is the responsibility of all aircraft maintenance personnel to conscientiously adhere to and follow preventive procedures and policies to eliminate ingestion of foreign objects by jet engines. Several areas of concern are parking and storage areas and procedures, engine installation, and engine ground operation. Frequent and periodic inspection of engine nacelles, inlet ducts, and storage areas is recommended. When required, careful cleaning of these areas should be accomplished. All maintenance personnel must exercise extreme care while performing maintenance procedures in and around the aircraft to prevent foreign object damage to the engines. The greater size of the newer jet engines creates greater suction pressures and larger suction areas. The higher suction pressures enable the engines to pull objects from greater distances into the engines compressor section. Objects may be picked up from the deck areas or from some areas within the aircraft which are directly or indirectly open to the engine bay or intake duct. Therefore, it is mandatory that personnel performing maintenance in and around the aircraft account for all tools, hardware, and components after all maintenance procedures and operations.

The turnup and taxi area of the jet engine must be cleaned frequently to insure that the area is free of such foreign objects as nuts, bolts, washers, tools, cotter pins, safety wire, stones, rags, etc. Numerous jet engines have been completely demolished because someone failed to police the turnup and taxi area for loose gear before the engine was started.

Anyone working in the vicinity of jet aircraft should insure that all personal effects such as hats, gloves, pens, and cigarette lighters are secured. These items may also cause foreign object damage.

EXTINGUISHING FIRES DURING GROUND TURNUP

At air stations or aboard a carrier, experienced crash crews and fire crews are readily available. The need for the services of the fire crews can, in most cases, be avoided by the prompt and efficient use of firefighting equipment which is available at all times on the flight line. It is of the utmost importance that every man working on the line be familiar with the location and use of the firefighting equipment.

CO_2 bottles are the most common fire extinguishers used on the line. These bottles contain a sufficient quantity of CO_2 to handle most small fires started on the flight line. An aircraft should never be fueled, defueled, or its engines started without having one or more men standing by with CO_2 bottles.

Some aircraft carry one or more small CO_2 bottles. These bottles are intended for use in flight and should never be used in ground operations except in extreme emergency. In the event that they are used, they should be replaced prior to the aircraft's next flight.

Whenever an engine is started, personnel with adequate fire extinguishers must always be maintained in the immediate vicinity of the engine. When available, a 15-pound CO_2 fire extinguisher is the minimum which should be used when starting an engine.

Firefighting Procedure

If a fire starts in the tailpipe of a turbojet; engine as it is being started, the engine should be given a dry start; that is, a start (motoring of the engine) with the switches which control the fuel in the OFF and CLOSED position.

If the fire persists, CO_2 can be discharged into the inlet duct so that it can be drawn through the engine while it is being given the dry run. CO_2 should not be discharged directly into the engine exhausts as this may damage the engine.

In case the fire is on the ground under the engine overboard drain, the CO_2 should be discharged on the ground rather than on the engine. This holds true also if the fire is at the tailpipe and the fuel is dripping to the ground and burning.

The methods described here are for emergency use only, because the fire department should always be notified when there is a fire in or near an aircraft. It the fire cannot be extinguished with the equipment at the scene, secure all switches, abandon the aircraft, and stand by to assist the fire department upon their arrival.

AIRCRAFT SERVICING

Servicing of aircraft includes replenishing of the fuel, oil, hydraulic fluid, and other consumable materials. Also included under this heading are checking the tires for proper inflation, struts for proper extension, and the various air storage units for proper pressure.

FUEL REPLENISHMENT

Identification of Aircraft Fuels

Aircraft engine fuels currently in use are classified into types and grades as follows:

1. Reciprocating engine fuels; i.e., AVGAS (aviation gasoline).

Grade	NATO Symbol	Color
80/87	F-12	Red
91/96	F-15	Blue
100/130	F-18	Green
115/145	F-22	Purple

2. Turbine engine fuels; i.e., JP (jet fuel).

Grade	NATO Symbol	Description
JP-4	F-40	Low vapor pressure type
JP-5	F-44	High flashpoint kerosene type

The NATO symbol is a code number assigned to a product after it has been classified as standardized between two or more countries. No product is allocated more than one NATO symbol, and a number once assigned is never used for any other product. The NATO symbol is clearly distinguishable from all other markings; for example $\boxed{\text{F-22}}$ will be used by all NATO countries to identify 115/145 aviation gasoline.

Refueling Safety Precautions

Aviation gasoline is a highly volatile liquid which gives off a vapor. This aircraft fuel vapor is heavier than air and will settle to the ground, accumulating in dangerous amounts in depressions, troughs, or pits; and when combined with air in the proper proportions, forms and explosive mixture.

The ignition of vapor from aircraft fuel may occur from static sparks, sparks from tools, hot exhaust pipes, lighted cigarettes, electrical devices, and similar sources. A violent explosion followed by fire will result if liquid gasoline is present.

On the other hand, fuels such as JP-4 have some of the same characteristics of gasoline, but by no means the same substance. Different characteristics such as lower vapor pressure and high aromatic content exist in this fuel; therefore, special precautions in its handling must be taken.

All existing fire precautions must be adhered to during the fueling process. Smoking is not permitted in the aircraft during fueling. Also, no smoking or naked lights (such as are produced by oil lanterns, candles, matches, exposed electric switches, sliprings or commutators, a dynamo or motor, any spark-producing electrical equipment, or any burning material) are permitted within 100 feet of an aircraft being refueled, or of fuel storage tanks. No lights other than approved explosion-proof lights are permitted within 50 feet of these operations, and no light of any sort may be placed where it may come in contact with spilled fuel. Warning signs should be posted as a precautionary measure.

All accidental spillage of aircraft fuels or other combustible liquids must be immediately removed by washing, covered with a foam blanket to prevent ignition, or neutralized by other means. The proper fire authorities must be notified any time a large amount of aviation fuel is spilled.

Aircraft fuel tanks must be filled, purged, of have an inert gas (such as CO_2) over the gas in the tanks before storing aircraft in hangars, since this leaves no space for explosive vapors to form.

Nonspark tools must be used when working on any part of a system or unit designed for storing or handling combustible liquids.

The use of leaky tanks or fuel lines is not permitted. Repairs must be made on discovery, with the regard to the hazard involved.

Gasoline must be strained if there is the slightest chance that water may be present in the fuel. Most fueling trucks and underground storage systems have filter/separators which automatically filter water out of the gasoline before delivering it to the aircraft tank. These filter/separators should be checked daily for dirt and water. This system serves the same purpose as the sediment bulb or tank in an automobile gasoline system.

Aircraft should be fueled in a safe place. Do not fuel or defuel an aircraft in a hangar or other enclosed space except in case of emergency. Aircraft should be free from fire hazards, have engine switches off, and chocks placed under the wheels prior to fueling or defueling.

As an AME striker, one of your duties might be standing by with a CO_2 fire extinguisher or other firefighting equipment while the aircraft is being refueled. The AME striker assigned to stand by the fire extinguisher should insure that the extinguisher is full (by inspecting for the lead seal on the release mechanism) and that he is familiar with the release mechanism on the type extinguisher in use. When fighting a fuel fire, it is most important that action be taken immediately; therefore, the fire watch should be alert at all times.

CAUTION: Guard against breathing hydrocarbon (fuel) vapors as they may cause sickness or may even be fatal. Do not let fumes accumulate—use adequate ventilating measures. Also, avoid getting fuel on clothes, skin, or in the eyes, because of the high lead content. Fuel-saturated clothing should be removed as soon as possible, and the parts of the body exposed to fuel washed thoroughly with soap and water. Wearing clothing saturated with fuel creates a dangerous fire hazard, and painful blisters may be caused by direct contact with fuel in the same manner as fire burns. When fuel has entered the eyes, medical attention should be obtained immediately.

When an aircraft is to be fueled by a truck, it should not be located in the vicinity of possible sources of ignition such as grinding, drilling, or welding operations. When practicable, a minimum of 50 feet from other aircraft or structures and 75 feet from any operating radar set should be maintained. Consideration must be given to the direction of the wind so that fuel vapors will not be carried toward a source of ignition.

The tank truck should be driven to a point as distant from the aircraft as the length of the hose permits, and preferably to the windward (upwind) side of the aircraft. It must be parked parallel to or heading away from the wing, or in such a position that it may be driven away quickly in the event of fire. As soon as the fueling operation has been completed, the truck should be removed from the aircraft's vicinity. The truck manway covers should be kept closed, except when a tank is actually being loaded, or when pumping fuel at 25° F or below, because at such temperatures vent valves may be inoperative.

NOTE: The operation of fuel trucks at many air stations is performed by civilian crews. Even though the Aviation Structural Mechanic E may not be called on to operate or drive fuel trucks, he must be thoroughly familiar with the entire procedure to insure safety of the fueling operation, in which be will be frequently involved.

Refueling crews usually include a minimum of three men. One person stands by with the firefighting equipment; another stays with the truck; and the third man handles the fuel hose at the aircraft and fills the tanks. A member of the crew makes sure that both the aircraft and the truck are properly grounded to prevent sparks from static electricity. A check should be made to see that all radio equipment and unnecessary electrical switches are turned off. Outside electrical power should not be connected to the aircraft unless it is necessary to operate the equipment involved with refueling. Care should be taken to identify the aviation fuel before beginning the refueling operation. Refueling trucks have the type fuel contained in the tanks painted across the side of the tank in black letters. An AME who is involved with servicing aircraft should become familiar with the various grades of fuel and the aircraft's fuel requirements in order to insure that the appropriate fuel is always used.

Gravity Fueling

Many naval aircraft are refueld by the gravity fueling system. (See fig. 10-9.) Some aircraft may be refueled by either the gravity or pressure fueling system, and other aircraft are fueled from a single point by the pressure fuelin system.

Gravity fueling is accomplished by grounding the nozzle, inserting the nozzle in the cell filler neck, and filling the tank to the bottom of the filler port neck.

The nozzle should always be grounded prior to being placed in the filler neck in order to prevent sparks caused by static electricity. The nozzle should be supported while in the filler neck to prevent damage to the filler neck and in the case of aircraft which use bladder type fuel cells (cells made from a type of rubberized nylon cloth) to prevent the possibility of damaging the cell with the end of the nozzle.

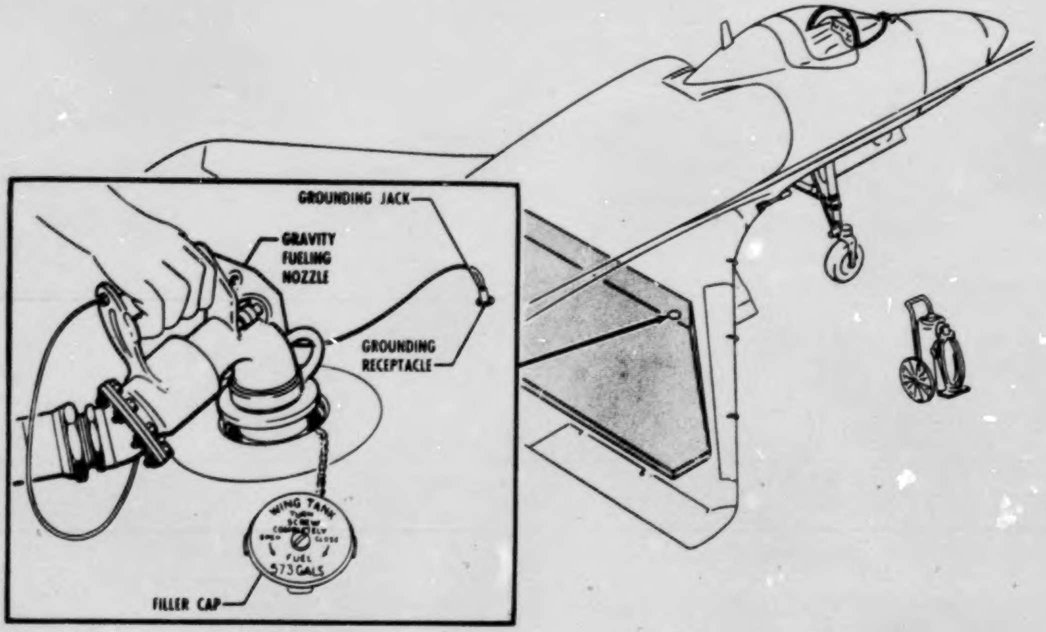
Pressure Fueling

Most of the newer naval aircraft are refueled by the pressure fueling system. This is employed to enable faster "operational turn around" of the aircraft.

Pressure fueling is usually accomplished from a single point. Fuel from this point is supplied to the various wing and fuselage tanks. In some cases, the drop tanks and flight refueling package may also be refueled from this point.

The pressure fueling station on the aircraft is equipped with a pressure fueling and defueling receptacle and an electrical control panel. (See fig. 10-10.) The pressure fueling receptacle is standard on all aircraft which use the pressure fueling method. The electrical panel and controls differ from one aircraft to another, depending upon the complexity of the fuel system. The more complex systems may require several switches and lights. The General Information and Servicing section of the applicable Maintenance Instructions Manual contains illustrations and instructions concerning the pressure fueling system.

The pressure nozzle shown in figure 10-10 is permanently attached to the refueler hose. The pressure nozzle is equipped with a ground wire which is used to drain off any static electricity which may have built up in the nozzle. However, once the nozzle is attached to the aircraft, it acts as its own ground.



AM. 201

Figure 10-9.—Gravity fueling.

As the connection is made, the pressure nozzle opens a spring-loaded valve within the inlet to the fuel tanks. Once the connection is made, there is no further need for grounding the other cells or tanks. Aircraft which employ the pressure fueling system are equipped with automatic equipment for shutting off the fuel flow when the tanks are full.

The following is a general procedure for pressure fueling an aircraft. Since the controls differ from one aircraft to another the applicable Maintenance Instructions Manual should always be checked prior to pressure fueling an aircraft.

1. Remove the pressure fueling receptacle safety cap by turning counterclockwise. Pull the pressure fueling nozzle dust cover up and to one side of the outer shell.

2. Ground the nozzle by inserting the grounding plug into its receptacle on the aircraft.

3. Lift the nozzle by its handles into position and engage the lower slot over the lower lug on the fueling receptacle. Tip the nozzle so that the upper slots engage the upper lugs. Press the nozzle in firmly so that all three nozzle lock keys are depressed. Lock the nozzle by rotating the lifting handles clockwise.

4. Set the refueling panel switches in the proper position and apply electrical power to the aircraft.

5. Position the vent monitors as necessary in accordance with the applicable Maintenance Instructions Manual. NOTE: The vent monitors are assigned to the various fuel system vents to insure that the aircraft's fuel cells are venting properly. Should the cells not vent properly, there is a possibility of rupturing the cell and even causing major structural damage.

6. With the nozzle locked in place, the opening handle is free to turn whenever fueling is to be started. To start fueling turn the handle to the FULL OPEN position. Rotating the opening handle more than 180 degrees opens the poppet valve in the nozzle and locks it in the OPEN position. Position the appropriate switch on the fuel panel to the FUEL position. The fuel should shut off automatically when the cells are full.

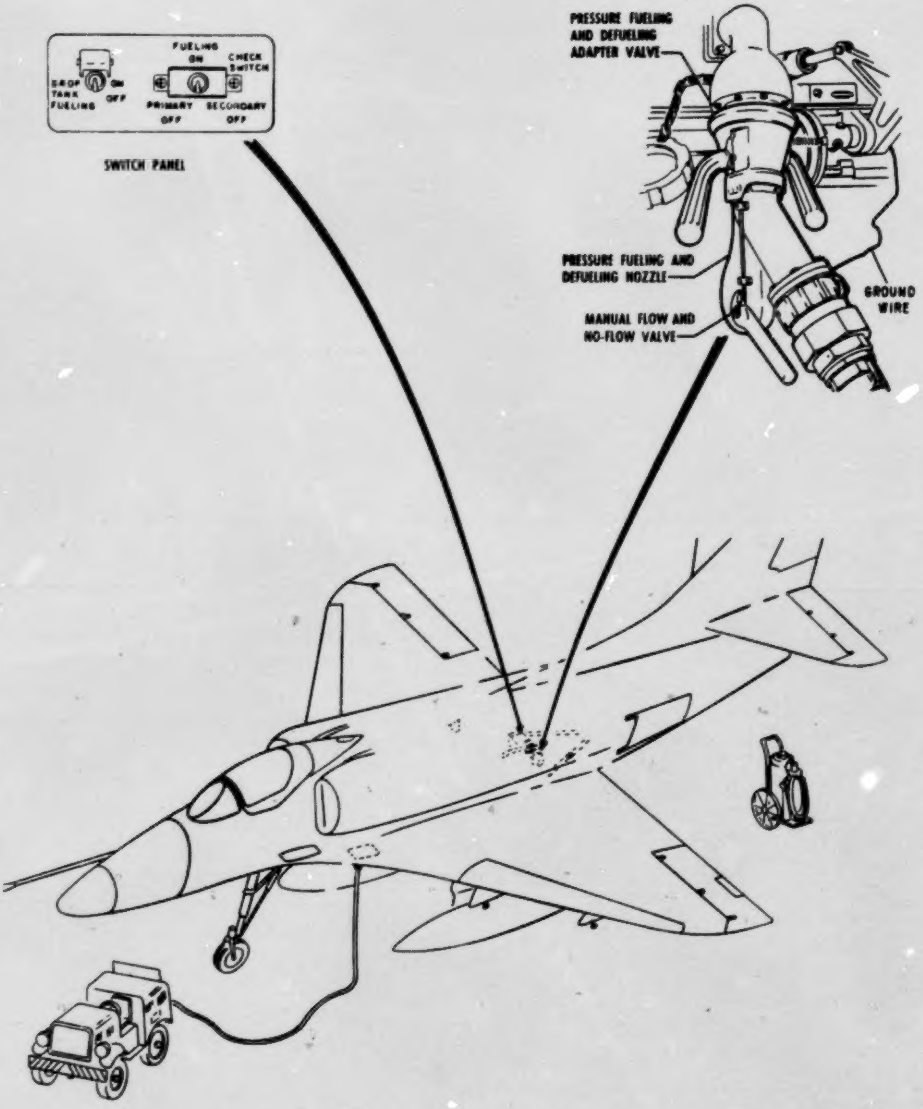

FUELING
ON
CHECK
SWITCH
DROP
TANK
FUELING
ON
OFF
PRIMARY
OFF
SECONDARY
OFF
SWITCH PANEL
PRESSURE FUELING
AND DEFUELING
ADAPTER VALVE
PRESSURE FUELING AND
DEFUELING NOZZLE
MANUAL FLOW AND
NO-FLOW VALVE
GROUND
WIRE
AM. 202

Figure 10-10.—Pressure fueling.

CAUTION: During pressure fueling, the fuel system should be inspected carefully for leakage. If any leaks are apparent, fueling should be stopped and corrective action should be taken.

7. When fueling is complete, the pressure fueling nozzle is removed by rotating the lifting handles counterclockwise until the nozzle is unlocked from the fueling receptacle. The dust cover should be pulled up over the nozzle face immediately and the safety cap replaced on the aircraft receptacle.

Every safety precaution must be taken to insure that no dirt or foreign matter enters the nozzle and that the nozzle nose is completely clean before it is connected to the aircraft. The dust cover must be kept on the nozzle at all times except when actually fueling an aircraft.

The pressure fueling nozzle can be damaged by careless handling. Guard against dropping the nozzle or allowing it to swing heavily against structures or equipment during handling. Never drag the nozzle on the deck.

Never force the operating action of the nozzle. If the unit does not couple freely or open or close readily, locate and correct the misalignment or mechanical jam.

Defueling

Defueling may be necessary for a variety of reasons such as fuel cell repairs, removal of external fuel tanks, failure of fuel system components, and changing of fuel loads.

Aircraft which utilize pressure fueling are normally defueled from the pressure fueling adapter which allows the entire system to be defueled from a single point. Some older aircraft are equipped with one or more defueling valves. Some residual fuel will generally be left in the bottom of fuel cells following defueling. Residual fuel can usually be emptied or drained through the fuel cell water drain valves, using a special draining adapter and appropriate container to catch the fuel. When defueling external fuel tanks, it may be necessary to insert the defueler hose in the filler port.

Defueling will normally be accomplished outside the hangar and under controlled conditions as specified in the General Information and Servicing volume of the applicable Maintenance Instructions Manual. If it is absolutely necessary to defuel an aircraft in the hangar, doors should be open to provide ventilation through the hangar and all shop doors leading into the hangar should be closed. No work should be accomplished on or around the aircraft during the defueling operation and all sources of ignition should be prohibited in the area. The safety precautions defined in NavMat P 5100, the applicable MIM, and local directives should be strictly adhered to at all times.

OIL REPLENISHMENT

Identification of Aircraft Engine Oils

Aircraft engine oils are identified by their military specification number and/or 4-digit numbers; for example, 1065. The 4-digit numbering system identifies the intended use of the oil and its viscosity. The first digit designates the intended use, lxxx series being for aircraft engine lubrication. The last three digits indicate the viscosity; for example, 1065 oil has a viscosity rating of 65, 1080 oil has a viscosity rating of 80, etc. Viscosity is defined as the internal fluid resistance to flow caused by molecular attraction. NOTE: Both the Navy and the Air Force use the Saybolt Scale for determining viscosity. Saybolt viscosity numbers should not be confused with SAE numbers.

The synthetic oils used in most turbojet engines are referred to by their military specification number; for example, MIL-L-23699.

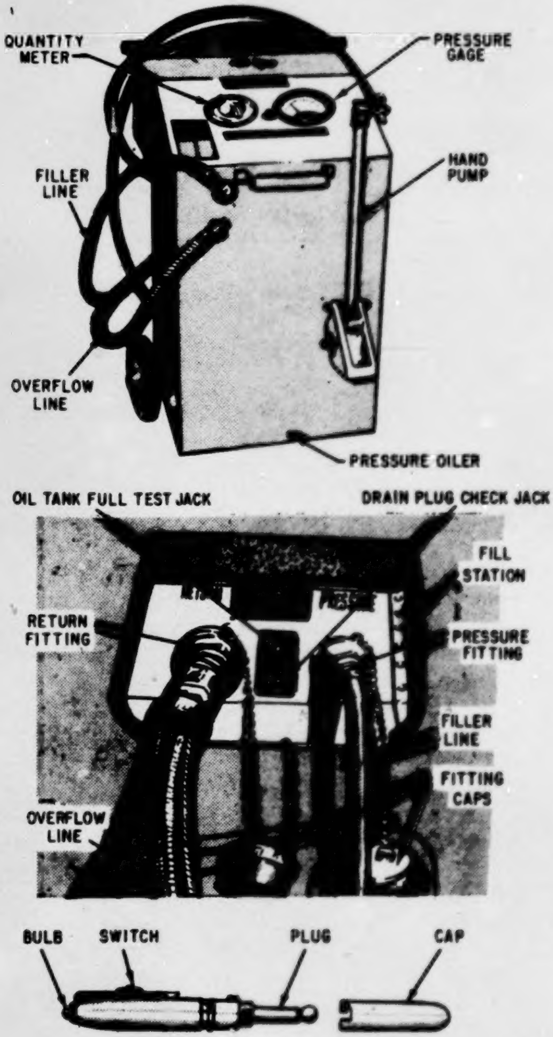
Servicing Engine Oil Tanks

Some aircraft engines utilize a combination dry and wet sump type of lubricating system while others are lubricated entirely with a dry sump type. Wet sump engines store the lubricating oil in the engine proper like automobile engines, while dry sump engines utilize an external tank mounted on or near the engine. Oil in jet engines serves the two fold purpose of lubricating and cooling.

Servicing of the engine oil system is usually a simple task of checking the tank for the proper oil level and bringing the oil level up to the required amount. On aircraft with a dry sump system, servicing may consist of pumping uncontaminated oil directly into the supply tank. However, on some aircraft the tank is located in an inaccessible compartment, and a pressure tank is required to fill the oil tank.

Figure 10-11 provides an example of the pressure oiler, the engine oil pressure fill station located in the engine nacelle, and the penlight (PON5-75) used in servicing the engines on E-2A and C-2A aircraft. Servicing consists of the following steps:

1. Set the penlight switch to ON, with the cap in place. The bulb should light.
2. Remove the cap and insert the plug into the OIL TANK FULL test jack (at the fill station). The bulb should go on. If the bulb does not light, oil level is low and servicing is required.
3. Remove the penlight from the oil tank fill test jack and with the switch still ON insert into the DRAIN PLUG CHECK jack. If the bulb lights it is an indication of an accumulation of metallic material on either or both engine magnetic chip detectors. Call such indications to the attention of the appropriate supervisory personnel. If the bulb remains out proceed with servicing.
4. Reinsert the penlight into the OIL TANK FULL test jack.



AM. 1211

Figure 10-11.—Oil System servicing equipment (E-2A/C-2A).

5. Insure that the pressure oiler is properly filled. Prime the supply line, reset the quantity meter to zero, and connect the oiler filler line to the pressure fitting and the overflow line to the return fitting at the fill station.

6. Pump oil into the system until the penlight bulb lights and note the quantity on the quantity meter. If oil consumption exceeds limits, notify the appropriate maintenance chief.

7. If oil consumption is within limits, continue pumping oil at a slower rate until oil flow is observed at the overflow discharge in the pressure oiler.

NOTE: Checking and filling of the engine oil system of most jet engines must be accomplished within a specified time limit after engine shutdown. In most cases if the engine is not serviced within these time limits, the oil system must be drained and refilled to insure a proper quantity of oil or the aircraft could be turned up to scavenge oil from the engine gear case to the oil tank. In all cases follow the servicing instructions provided in the appropriate Maintenance Instructions Manual.

If unusually high oil consumption is noted, maintain an accurate record of consumption as specified by the applicable inspection requirement or the MIM. Oil consumption can be a reliable indicator of impending engine malfunction and a determining factor in deciding whether an engine is acceptable for flight status.

CAUTION: Do not overfill engine oil systems. The system previously discussed requires filling to overflow, however, some aircraft oil systems require that adequate space be allowed for normal foaming of the oil and expansion when the engine is operating.

Servicing Constant Speed Drive Assemblies

Several late model reciprocating and jet engine aircraft utilize a constant speed drive (CSD) assembly to maintain the aircraft's generator(s) at a constant speed. The assembly transfers and converts variable speed rotation of the aircraft engine into a constant speed rotation necessary to drive the generator at a constant speed which will meet all the aircraft's electrical demands.

At least one aircraft features a combination constant speed drive/starter (CSD/S) which provides both pneumatic starting for the engines and constant speed drive for the generator. This CSD/S can be operated in engine starter, constant speed drive, or air turbine motor modes of operation.

Proper operation of any CSD assembly is extremely dependent on proper servicing by personnel assigned to line maintenance. In most cases the CSD or CSD/S must be serviced within a specified period after engine shutdown to obtain an accurate oil level reading. If this time is exceeded the oil reservoir must be drained prior to servicing with the required volume of specified lubricating oil or the aircraft turned up so that the oil level can be checked within the designated time limit.

Several types of lubricating oils are utilized in the various types of CSD assemblies found in naval aircraft. Use only the specified oil indicated in the General Information and Servicing volume of the MIM for the particular aircraft being serviced. Improper lubrication can cause internal damage and disastrous failure. To allow for normal expansion and some foaming of the oil under use, do not overfill the oil tank.

NOTE: The synthetic oil used in some aircraft engines and CSD assemblies is harmful to human skin and respiratory tract, and has a deteriorating effect on rubber and painted surfaces. Handle in such a manner as to prevent skin contact and/or damage to the aircraft finishes.

The presence of contamination in the lubricating system of aircraft engines and CSD units can be as disastrous to their operation as the presence of contamination in oxygen, hydraulic, and fuel systems. Proper handling of lubricants and servicing equipment and strict conformance to servicing instructions provided in the MIM will minimize the possibility of introducing external contamination. Any suspected contamination should be immediately called to the attention of the appropriate maintenance supervisor.

HYDRAULIC FLUID REPLENISHMENT

Identification of Hydraulic Fluid

Aircraft hydraulic fluids are identified by their military specification number. Hydraulic fluid, MIL-H-5606B, is now being used in the hydraulic systems of all naval aircraft. This fluid is also used in the shock struts, shimmy dampers, and brake systems of all aircraft. MIL-H-5606B hydraulic fluid is colored red and is available in 1-quart, 1-gallon, 5-gallon, 55-gallon containers and 16-ounce spray cans. The spray can is utilized for spraying the exposed portion of actuating cylinders and struts required on most daily aircraft inspections.

NOTE: Hydraulic fluid MIL-H-6083C is a preservative type hydraulic fluid used in the preservation of hydraulic systems and components. While it is red in color and generally considered compatible with MIL-H-5606B hydraulic fluid, it should NOT be used to service aircraft hydraulic systems.

Servicing Hydraulic Systems

Older type aircraft hydraulic systems are serviced by checking the fluid level (on a sight gage which is usually located on the side of the reservoir) and filling to the prescribed level. Before adding fluid to this type reservoir, always check the reservoir instruction plate for proper filling instructions. The instructions plate will be attached either to the reservoir or to the aircraft structure near the filler opening of the reservoir. The instruction plate contains the foling information:

Total capacity of the system.
Reservoir capacity.
Refill level.
Specification and color of fluid.
Correct position of all actuating cylinders during filling.
Any other information considered necessary during the filling of the reservoir.

NOTE: After opening a can of hydraulic fluid, the entire contents should be poured into the fill stand or servicing unit immediately. This will eliminate the possibility of the fluid absorbing dust and grit from the air. Current instructions require that any remaining fluid left in the hydraulic fluid container, after servicing a fill stand/servicing unit, be discarded and that the empty fluid container be destroyed immediately and not used to store or handle any other fluid.

Hydraulic systems can only be serviced with approved 3-micron absolute filtered dispensers. Figure 10-12 shows a fill stand used to service some aircraft hydraulic systems. The fill stand is connected to the aircraft hydraulic system at a quick disconnect which is provided for reservoir filling. The fill stand can be operated with air pressure or using the handpump. Some aircraft systems provide for filling several reservoirs from a single point while others have provisions for filling each reservoir individually.

Another type of hydraulic servicing unit, shown in views A and B of figure 10-13, is a portable hand-operated unit designed to accept the standard 1-gallon can of hydraulic fluid and to dispense it contamination free to aircraft hydraulic reservoirs. This is done by pumping the hydraulic fluid from the original container, which functions as the unit's reservoir, directly into the aircraft's reservoir without exposing the fluid to open air or other atmospheric contamination. In addition, waste of hydraulic fluid is reduced since a partially used can of fluid does not have to be thrown away but can be retained in its contamination-free condition, in the unit, until it is needed and used on another job.

This type of servicing unit comes unpainted and is to remain as such to eliminate the possibility of paint chips getting into the aircraft hydraulic system and contaminating them. All exposed parts of the unit have either been plated

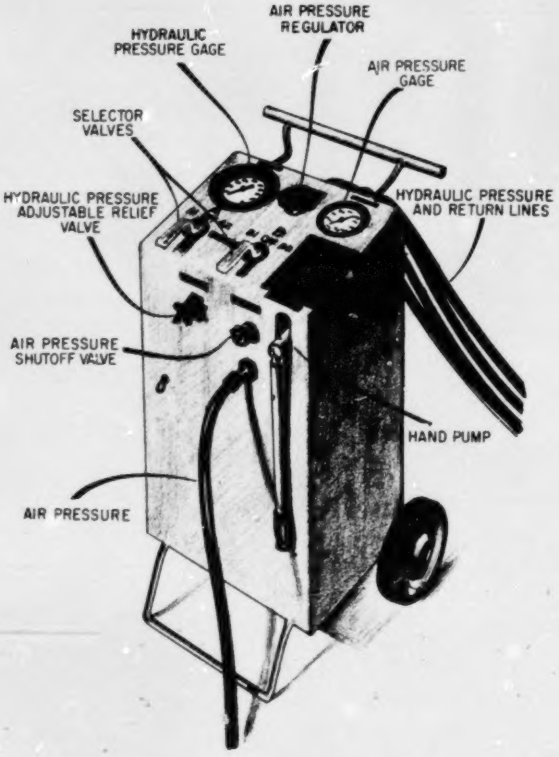

AIR PRESSURE REGULATOR
HYDRAULIC PRESSURE GAGE
AIR PRESSURE GAGE
SELECTOR VALVES
HYDRAULIC PRESSURE ADJUSTABLE RELIEF VALVE
HYDRAULIC PRESSURE AND RETURN LINES
AIR PRESSURE SHUTOFF VALVE
HAND PUMP
AIR PRESSURE

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Figure 10-12.—Hydraulic fill stand.

or are of hard anodized aluminum. The unit is also constructed so that it can stand on a 15-degree slope without turning or sliding and has a neoprene strip on its base to prevent scratching or marring any surface on which it rests.

In addition, this unit provides exceedingly fine filtration through the use of 3-micron filters which remove minute particles that may be in the fluid. With the use of this unit, the can of fluid is sealed into the unit, and the fundamental feature of preventing contamination from exposing the fluid to the atmosphere and other external contamination is accomplished.

Most of the newer type aircraft have a visible means (usually sight gages) for checking fluid level; however, some are equipped with lights which indicate fluid level.

Information concerning servicing of the hydraulic reservoirs of a particular type aircraft is contained in the General Information and Servicing volume of the applicable Maintenance Instructions Manual.

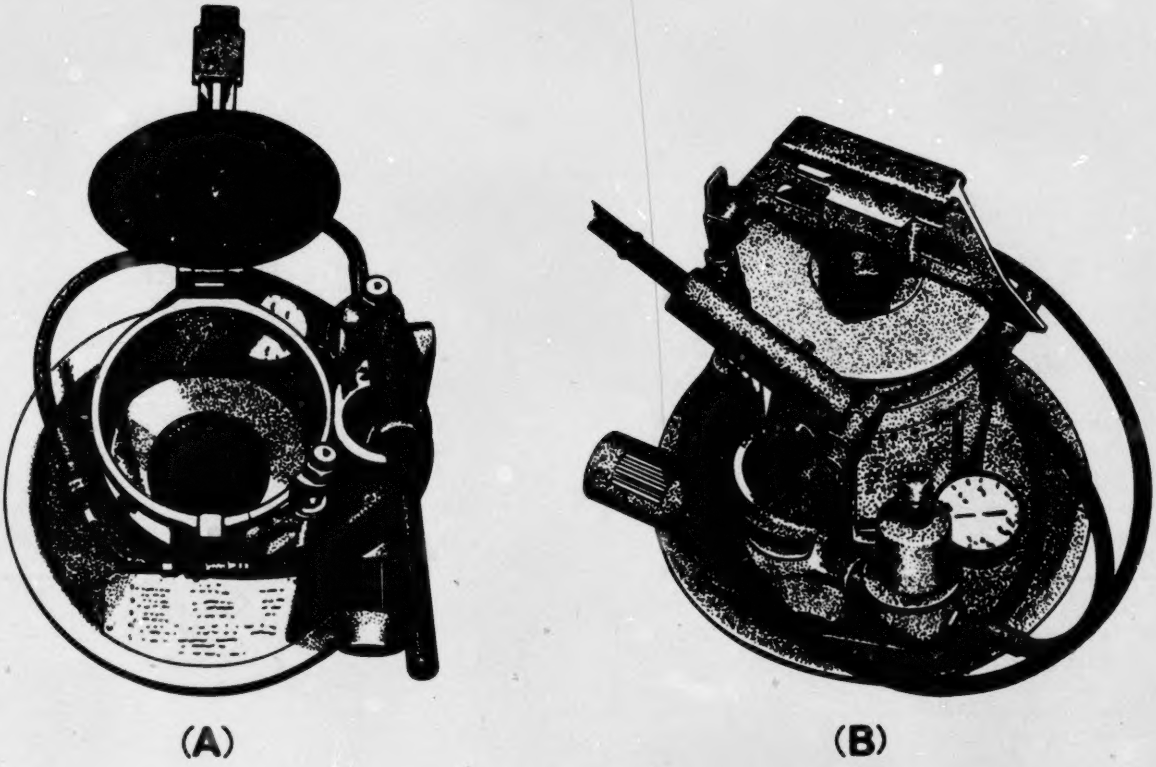
OXYGEN REPLENISHMENT

Oxygen used for aviator's breathing is procured under Military Specification MIL-O-27210D. It is procured in two types; Type I is gaseous oxygen, and Type II is liquid oxygen (LOX). Oxygen procured under Specification BB-0-925A is intended for technical use and should not be used in aircraft oxygen systems.

Gaseous Oxygen System Servicing

Gaseous oxygen systems are serviced from servicing trailers such as the type NO 2 discussed in chapter 7. The danger involved in the transfer of gaseous oxygen as well as its importance to the pilot requires that it be handled with care. The following general safety precautions should be adhered to for safe operation of the oxygen servicing trailer:

1. Only qualified operators should operate the trailer for recharging aircraft oxygen systems. Complete familiarity with the trailer is a basic prerequisite to safe operating techniques.
2. The aircraft electrical system must be turned off and no other servicing should be conducted on the aircraft while servicing the oxygen system.
3. Never permit oil, grease, or other readily combustible materials to come in contact with oxygen cylinders, valves, regulators, gages, or fittings.
4. The servicing hose and aircraft connection fittings must be thoroughly inspected prior to servicing, and any trace of oil, grease, or foreign material carefully removed.
5. The servicing hose should always be bled prior to connecting with the aircraft oxygen system.
6. Open all valves slowly.
7. Always know the pressure existing in the aircraft system to be filled and the pressure in all cyclinders to be used in the refilling process before commencing the recharging operation.
8. Insure that the line valve on the discharge end of the servicing hose is closed at all times when not actually servicing aircraft.
9. Never have more than one cylinder control valve open during operation.
10. The servicing hose must never be tightly stretched to reach a connection. Position the trailer so that the hose is not under tension.



AM. 902

Figure 10-13.—Loe Hydraulic Servicing Unit, Model H250-1.

11. When disconnecting the transfer hose from an aircraft fitting, loosen the connection slowly to prevent rapid bleeding of the trapped oxygen.

12. A malfunctioning pressure regulator should be disconnected from the line by closing its associated shutoff valves. The trailer can then be operated with the remaining pressure regulator.

13. When moving the trailer from place to place, cylinder valves should be closed.

Before servicing an aircraft gaseous oxygen system care should be taken to insure that the six manifold control valves on the trailer control panel are closed. If these valves are partially opened, the cylinder pressure will equalize from one to the other.

The following is a general procedure for servicing a high-pressure oxygen system. NOTE: Since aircraft oxygen systems vary in design, always check the applicable Maintenance Instructions Manual or Maintenance Requirements Card prior to servicing in aircraft oxygen system.

1. Prior to servicing (recharging) an aircraft gaseous oxygen system, insure that the following conditions exist on the aircraft and the oxygen servicing trailer.

a. The trailer and aircraft should be properly grounded.

b. The line valve on the oxygen servicing hose should be closed.

c. All six trailer manifold control valves should be closed.

d. Both pressure regulators and their associated shutoff valves should be closed.

e. All six individual cylinder valves should be opened and the individual cylinder pressures noted.

2. Open the cylinder valve and then the manifold control valve on the cylinder with the lowest pressure above the aircraft system pressure.

3. Open the two shutoff valves on each side of the pressure regulator valve which is to be used. NOTE: The oxygen servicing trailer is equipped with two pressure regulators so that in the event of the failure of one, the other may be used.

4. Slowly open the pressure regulator valve (by turning the control knob clockwise) and allow the pressure to build up to the trailer cylinder pressure. The set pressure of the regulator may be noted on the regulator gage.

NOTE: A temperature correction chart is given in the applicable Maintenance Instructions Manual or on the side of the servicing trailer. This chart is used to determine the pressure to which the aircraft cylinders should be filled. This pressure depends on the ambient temperature, as may be noted on the thermometer on the trailer manifold stand.

5. Slowly open the service valve on the servicing hose and bleed the hose to insure that all loose foreign matter that might be within the hose is expelled.

6. Close the service valve on the hose and attach a high-pressure adapter to the coupling nut on servicing valve.

7. Open the access panel to the aircraft oxygen filler valve. Check the filler valve and the area around the filler valve for any trace of oil, grease, or any other foreign material. Clean the area if necessary. Unscrew the dust cap from the filler valve.

8. Connect the service hose high-pressure adapter to the aircraft filler valve.

9. Slowly open the service valve on the hose. When there is no longer a flow of gas (lower manifold gage is within 15 pounds of the supply cylinder gage), close the cylinder valve and the manifold control valve, and repeat the process with the cylinder with the next higher pressure. Work cylinders in increasing order of their pressure until the aircraft system pressure has reached the desired reading.

NOTE: Oxygen under high pressure will increase in temperature during the servicing procedure. In order to obtain the desired pressure in the aircraft system, cylinders should be filled slightly above 1,800 psi (+ 50 to + 200 psi), depending upon the ambient temperature.

10. After fully charging the aircraft system, close the service hose valve, shutoff valves, pressure regulator and associated shutoff valves, manifold control valve, and cylinder valve in that order.

11. Disconnect the servicing hose from the aircraft filler valve and relieve the hose pressure by opening the service valve on the hose.

12. Close the service valve and stow the hose in the trailer hose basket.

13. Replace the aircraft filler valve dust cap and the access plate.

Liquid Oxygen System Servicing

Liquid oxygen is one of the most dangerous materials with which the AME may come in contact. The potential hazards in handling liquid oxygen are the result of its chemical activity and two of its properties: extreme cold and expansion upon conversion to gas.

Because of its extremely low temperature, liquid oxygen can freeze or seriously damage human tissue on contact. The effects are similar to those caused by frostbite or burn. When working with liquid oxygen, take care to stand clear of boiling and splashing liquid. Be particularly careful when filling a warm container as vigorous boiling, sloshing, and gasification may take place. Liquid oxygen boils at -183° C or -297 °F. The critical temperature of oxygen is -118° C or -182°F, and the critical pressure is 735 psi. Any further increase in pressure will not prevent liquid oxygen from evaporating at this temperature.

Under certain humidity conditions, lines and connections on liquid oxygen plumbing will freeze and water vapor from the atmosphere will condense and freeze on uninsulated parts. If these areas are touched without protection, they may freeze to the skin on contact. Flesh tearing and severe cold injury may be suffered in attempts to get free.

Spilling of liquid oxygen in a poorly ventilated area will so enrichen the atmosphere that it presents a severe fire hazard. If exposed to liquid oxygen under certain conditions of temperature and pressure, some organic materials and flammable substances react violently with it. (These include oil, grease, dirt containing oil or grease, tar, asphalt, gasoline, kerosene, JP fuel, propane, butane, alcohol, ether, hydrogen, illuminating gas, acetylene, paint, cloth, and wood.) If exposed to liquid oxygen, these materials will burn violently, even when ignited several minutes after exposure. If vapor from liquid oxygen mixes with fuel vapor in certain proportions, the mixture will explode in the presence of a sufficient source of ignition. These mixtures are also percussion sensitive and will explode if subjected to certain shocks.

All combustibles are potential explosion hazards when mixed with liquid oxygen. Mere mixture of liquid oxygen with powdered organic materials under certain conditions may cause explosion.

The following general precautions apply to handling liquid oxygen:

Do not operate liquid oxygen equipment unless qualified or working under the supervision of qualified personnel.

Goggles or safety glasses with side shields or a face shield should be worn when handling liquid oxygen.

Do not handle with bare hands any tubing or fittings through which liquid oxygen is flowing. Wear clean, dry gloves when handling parts of equipment cooled by liquid oxygen. Leather gloves are preferable, but asbestos gloves may be used if they are treated or lined to prevent the penetration of splashed liquid. Gloves should be loose-fitting so that they can be thrown off quickly if any of the liquid oxygen gets into them.

In the event that liquid oxygen is spilled on clothing, remove the clothing immediately and air it promptly. In general, all clothing should be worn so that in the event of spillage, the liquid will roll off the clothing and not become trapped in gloves, shoes, or pockets. Other items of protective clothing advisable are plastic or rubberized fabric aprons; high top shoes or rubber boots; and cuffless trousers worn outside the shoe tops. The clothing should not have pockets, and sleeves and trousers should not be rolled up.

In the event that the body comes into contact with liquid oxygen or there is reason to suspect some part of the body has been frozen or chilled, thaw the exposed area, preferabley by immersion or by bathing it in water which is slightly above normal body temperature; wrap the exposed area loosely with clean, dry dressing; and report to a doctor immediately. Do not apply anything else to the affected area other than the clean, dry dressing.

Do not permit smoking, open flames, or sparks in the liquid oxygen handling areas.

Do not carry matches in liquid oxygen handling areas.

Keep work area and equipment free from oil, grease, or any other combustible material.

Keep tools and clothing free from oil and grease.

Avoid spilling liquid oxygen on floor or deck areas. In case of accidental spillage, ventilate the area thoroughly.

Always call oxygen by its proper name. Do not confuse it with compressed air. Never use oxygen in place of compressed air for any purpose.

Handle converters, storage tanks, and transfer equipment with care to avoid damage to the insulating space.

When transferring liquid oxygen, do not leave valves open all the way. Open valves wide, and then immediately close them about one-fourth turn; otherwise they may freeze in the open position.

Disconnect filling or transfer lines as soon as the transfer process is completed.

Do not leave liquid oxygen in a closed container or trapped in a line between two valves; always open a valve on one end to avoid excessive pressure buildup.

Use only standard approved equipment in the handling and storage of liquid oxygen.

Do not introduce moisture into the system. Exercise care to insure that no moisture is present on filler valve nozzles when they are connected or disconnected.

Purge piping and equipment with dry, water-pumped nitrogen or gaseous oxygen before and after making any repairs.

When transferring liquid oxygen aboard ship, position the transfer trailer so that it will not shift with the pitch and roll of the ship. Lock the brakes and tie down the trailer.

Before recharging an aircraft liquid oxygen system make sure that the aircraft is in an open, ventilated area; that the aircraft is not being fueled; that the aircraft electrical system is OFF; and that the aircraft is static grounded.

NOTE: Some operating commands require additional static grounds. These include grounding the liquid oxygen trailer to the deck as well as to the aircraft. These additional precautions have merit due to the fact that static charges may be built up during previous servicing and transfer hose purging as well as during movement of the trailer about the line.

There should be no auxiliary power units or starting units connected to the aircraft or operating elsewhere in the vicinity.

A CO_2 fire extinguisher should be immediately available.

All personnel should be kept clear of the aircraft overboard vent.

Even though it is possible for one man to service an aircraft liquid oxygen system, two qualified men should be present during every servicing operation. The second man is the safety and backup man. The second man should observe the first operator's every move to insure that safety precautions are complied with and in the event of an accident to secure the equipment, render first aid, or man the fire extinguisher if necessary.

Before liquid oxygen can be transferred from the servicing trailer, it is first necessary to build up the tank pressure. The following steps should be performed in preparing the servicing trailer:

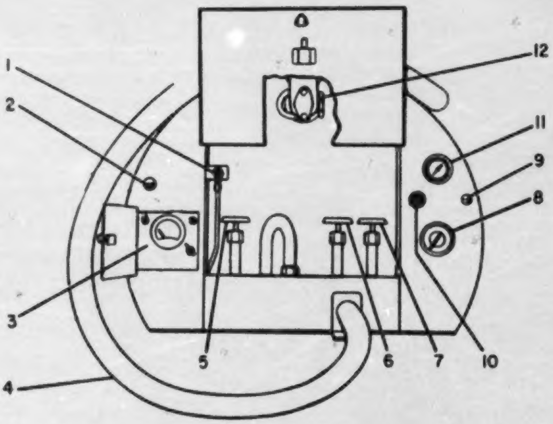
1. Check the supply of liquid oxygen in the trailer by closing the capacity gage valve (10, fig. 10-14) and noting the level indicated on the gage. NOTE: The capacity gage valve should be reopened immediately to prevent damage to the gage.
2. Check both pressure relief valves (2 and 9) for freedom of operation.
3. Close the vent valve (5), and check to be sure that the fill-drain valve (6) is closed.
4. Slowly open the pressure buildup valve (7) and allow the tank pressure to build up. Observe the tank pressure on the tank pressure gage (11). When a reading of 25 to 30 psi is reached, close the buildup valve and proceed with the transfer of liquid oxygen.

The valves on the control panel of liquid oxygen trailers are color coded for easy identification. Table 10-1 gives valve identification (valve name, letter designation, and color) and the position of each during pressure buildup and transfer conditions.

After the tank has been pressurized, position the trailer so that the transfer hose will reach the aircraft liquid oxygen converter (fig. 10-15) and proceed as follows:

Remove the transfer hose from its trough.

Remove the dust cap from the filler valve of the transfer hose. Place the hose filler valve firmly and squarely against the puring device (1, fig. 10-14). Open the fill-drain valve. Watch the pressure gage and open the pressure buildup valve as necessary to maintain a pressure of 25 to 30 psi. Continue purging until liquid oxygen flows in a steady stream from the purging device drain line. Purging cools the hose and filler valve, thus saving time in servicing converters.



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1. Purging device.
2. Tank pressure relief valve No. 1.
3. Vacuum gage and controls.
4. Transfer hose.
5. Vent valve "E" (red).
6. Fill-drain valve "C" (blue).
7. Pressure buildup valve "D" (white).
8. Capacity gage.
9. Hose pressure relief valve No. 6.
10. Capacity gage valve "B" (black).
11. Pressure gage.
12. Vacuum valve "A" (yellow).

Figure 10-14.—Liquid oxygen trailer control panel.

NOTE: While purging, turn the filler valve occasionally to keep it from freezing to the purging device.

CAUTION: A clean container should be placed under the purging device drain line.

Open the pressure buildup valve and allow the tank pressure to build up. The LOX trailer tank should be pressurized in accordance with the Operation and Service Instructions Manual for the particular type trailer. The instructions for the use of the Type NO 4 LOX trailer specifies that the tank pressure should not exceed 50 psi. Most transfers with this equipment may be made at 30 psi.

NOTE: The aircraft and the servicing trailer must be grounded prior to servicing the aircraft LOX converter.

Table 10-1.—Valve data.

Servicing Trailer Valves

Valve Identification			Functions	
Letter	Valve knob color	Valve name	Pressure buildup	Transfer
A	Yellow	Vacuum	Closed	Closed
B	Black	Capacity gage	Open	Open
C	Blue	Fill-drain	Closed	Open
D	White	Pressure buildup	Open	Closed*
E	Red	Vent	Closed	Closed

*When the pressure falls below transfer pressure, it will be necessary to open valve "D" until desired pressure is obtained.

Open the access door to the aircraft converter filler valve and remove the dust cap. Connect the transfer hose to the converter filler valve.

NOTE: Some aircraft LOX systems must be manually vented before connecting the hose filler valve to the converter filler valve.

Fill the converter until liquid oxygen flows from the overboard vent line in a steady stream. The first amount of liquid oxygen (1 to 2 liters) to flow into the converter will be evaporated in cooling down the converter and will produce a great amount of gaseous oxygen. This gaseous oxygen will flow out the overboard vent line. When this flow of gaseous oxygen slows down, liquid is entering the converter. The converter is considered to be full when a steady stream of liquid flows out the overboard vent.

CAUTION: A clean drain pan should be placed under the converter overboard vent line to catch the liquid oxygen which flows out as the converter is filled.

After filling is completed, close the fill-drain valve on the trailer. Relieve pressure in the transfer hose by connecting the hose filler valve to the purging device.

Replace the dust cover on the transfer hose filler valve.

Open the trailer vent valve (5, fig. 10-14).

Replace the converter filler valve dust cover.

Close the converter access door.

Draining Liquid Oxygen Converters

Liquid oxygen converters must be drained occasionally for maintenance and periodically for purging. Draining may be accomplished with the converter installed or removed. Draining should be accomplished in accordance with the instructions contained in the applicable Maintenance Instructions Manual.

Draining is usually accomplished by removing the supply quick disconnect from the

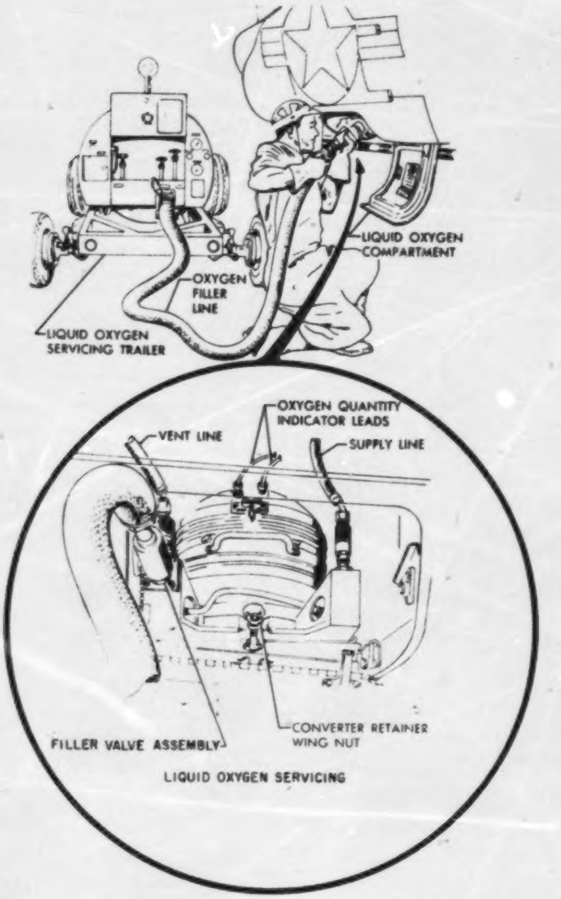
LIQUID OXYGEN COMPARTMENT
OXYGEN FILLER LINE
LIQUID OXYGEN SERVICING TRAILER
OXYGEN QUANTITY INDICATOR LEADS
VENT LINE
SUPPLY LINE
CONVERTER RETAINER WING NUT
FILLER VALVE ASSEMBLY
LIQUID OXYGEN SERVICING

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Figure 10-15.—Liquid oxygen transfer.

converter and installing a drain line which is equipped with a quick disconnect and placing the open end in a suitable container. Draining should be accomplished in an open, well-ventilated area. A fire extinguisher should be readily available.

NOTE: Protective clothing should be worn when draining a liquid oxygen converter to avoid being splashed with liquid oxygen.

The drained liquid oxygen should be left in the open and allowed to evaporate.

PNEUMATIC SERVICING

Landing gear struts, hydraulic accumulators, and various air storage bottles throughout most naval aircraft must be serviced with compressed air or nitrogen.

Pneumatic Servicing Equipment

The three main types of pneumatic servicing equipment are the portable nitrogen/air bottle, the air or nitrogen servicing trailer, and the portable, high-pressure air compressor.

PORTABLE NITROGEN/AIR BOTTLES.—The portable nitrogen/air bottle is a small high-pressure cylinder in a tubular steel frame. It has a pressure regulator and two gages. One gage indicates cylinder pressure and the other indicates regulated pressure. A valve mounted on the cylinder allows the user to shut the air off when the bottle is not in use.

Each portable nitrogen/air bottle has recharge and servicing instructions printed on a plate which is attached to the frame. Only dry filtered air or nitrogen should be used in recharging a nitrogen/air bottle which is to be used in servicing aircraft components. When recharging a portable nitrogen/air bottle, care should be taken to insure that the cylinder pressure does not exceed that listed in the instructions.

AIR OR NITROGEN SERVICING TRAILER.—A servicing trailer similar to the one shown in figure 10-16 will be found at most naval air activities for servicing aircraft hydraulic and pneumatic systems. This trailer is designed to carry six air or nitrogen storage cylinders and the necessary flow controlling mechanisms. It has a 30-foot hose which is stowed in a box mounted between the top two bottles.

The air or nitrogen servicing trailer has a purifier (dehydrator) assembly. This purifier assembly is essentially a reservoir which contains a chemical drying agent. This chemical drier is provided to remove any moisture which may have adhered to the valves or have been accidentally introduced into the system. The chemical is contained in a metal cartridge or can which is changed periodically. The gas passes through the drier just before it enters the servicing hose.

The trailer has a set of manifold control valves and two regulator valves similar to those found on the gaseous oxygen trailer.

The bottle on the air or nitrogen servicing trailer may be recharged using a high-pressure compressor.

NOTE: When recharging the cylinders on the air or nitrogen servicing trailer, insure

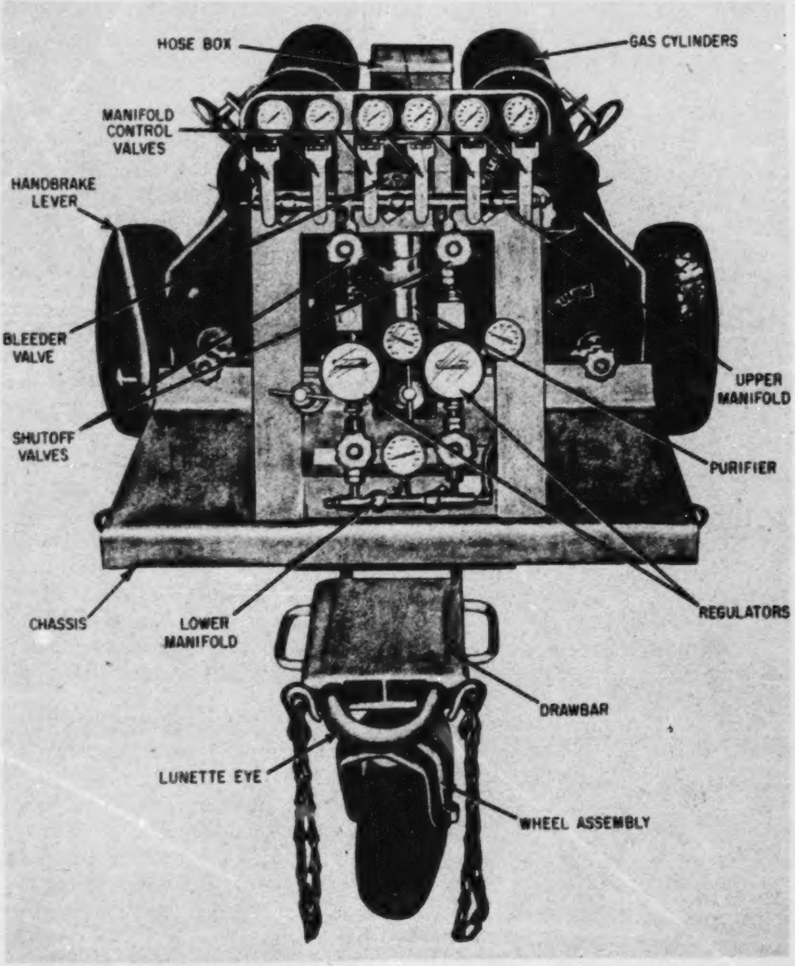
HOSE BOX
GAS CYLINDERS
MANIFOLD CONTROL VALVES
HANDBRAKE LEVER
BLEEDER VALVE
UPPER MANIFOLD
SHUTOFF VALVES
PURIFIER
CHASSIS
LOWER MANIFOLD
REGULATORS
DRAWBAR
LUNETTE EYE
WHEEL ASSEMBLY

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Figure 10-16.—Air or nitrogen servicing trailer.

that the cylinder pressure does not exceed the pressure specified for the equipment being recharged.

When operating the servicing trailer, the following precautions for safe operations should be observed.

Only a qualified operator should operate the trailer while charging a system or component. Complete familiarity with the trailer is a basic prerequisite to safe operating techniques.

The servicing hose end and installation connection fitting should be throughly inspected prior to servicing and any particles of foreign material removed.

Never charge a system or component without the proper fusible safety plug and blowout disc in the trailer charging system.

Always know the pressure existing in the system to be filled and the pressures in all the cylinders to be used up in the cascading process before commencing charging operation.

A malfunctioning pressure regulator should be disconnected from the line closing its associated shutoff valve. The trailer can then be operated with the remaining regulator.

The charging hose must never be tightly stretched to reach a connection. Position the trailer so that the hose is not under tension while servicing an aircraft.

After servicing an aircraft system, the servicing hose should be stowed in its container to insure that it is not damaged by dragging along behind the trailer.

AIR COMPRESSORS.—There are many models of compressors in use throughout the Navy. Such a variety makes it difficult, at best, for the average man to be master of all. The situation is further complicated by the variety of configurations of dials and gages, regulator controls, hoses, and hose fittings on the same model compressor.

Most air compressors have an instructions plate mounted on the control panel to aid in proper operation. These instructions plates should be kept in good condition; that is, they should not be painted over or scratched and marred. If the instructions plate is not available on the compressor, the Operations and Service Instructions Manual for the particular air compressor will contain all the necessary instructions for the operation and maintenance of the compressor.

Most of the newer high-pressure type air compressors will supply air pressure from 0 to 5,000 psi. Handling of compressed air at pressures up to 5,000 psi requires extreme caution. The following servicing instructions will help to insure a safe job:

1. Always use a remote control pressure gage that is not defective and is properly calibrated. NOTE: In accordance with current instructions, all gages used in servicing aircraft hydraulic and pneumatic systems must be calibrated periodically to insure their accuracy.
2. Never use an uncontrollable source of high-pressure air. Always use a regulator in the air system.
3. Always open the control valves slowly. Inflate the component slowly—10 psi increments—until the recommended pressures are reached.

High-pressure air compressors like the air or nitrogen servicing trailer are equipped with one or more dehydrators. The cartridges used in these deydrators must be replaced periodically, depending upon the weather conditions. In damp, humid weather it will be necessary to replace the dehydrator cartridges more often than in dry, arid weather.

High-Pressure Air Valve

The high-pressure air valve shown in figure 10-17 is used on most naval aircraft. This air valve (referred to by its MS number, MS 28889-1) is used on struts, accumulators, air storage bottles, and various other components which must be serviced with high-pressure air. Unlike the old type high-pressure air valve (AN 6287), which may be found occasionally on old type aircraft, the MS 28889-1 air valve has no valve core.

When servicing a system equipped with a high-pressure air valve, exercise extreme caution. If a system is low on pressure, this is generally an indication of a leak that must be found and corrected. To release the air pressure from a system equipped with a high-pressure air valve, remove the dust cap from the valve and release the pressure by slowly turning the swivel nut counterclockwise.

CAUTION: When loosening the swivel nut, make sure the hex body nut is either lockwired in place or held tight with a wrench. If it is

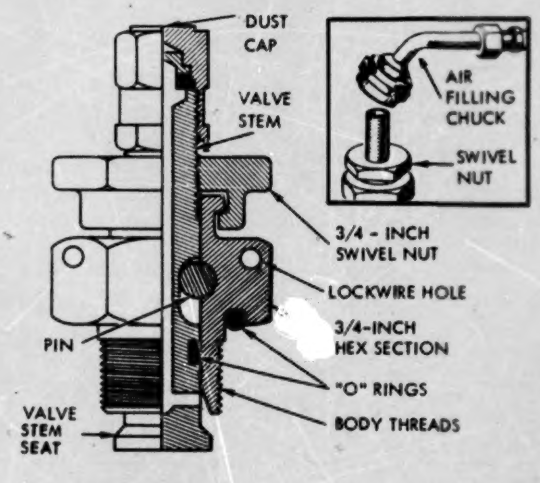

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Figure 10-17.—High-pressure air valve, MS 28889-1.

loosened before the air pressure is relieved, serious injury may result.

If it becomes necessary to replace a leaking high-pressure air valve, reinstall the new air valve assembly, using a new O-ring packing. The recommended torque for tightening the hex body is 100 to 110 inch-pounds. After the hex body is torqued, it is lockwired to the component or surrounding structure as specified in the Maintenance Instructions Manual, using the holes provided in the hex body nut.

When the correct pressure has been reached in a system being serviced, the air valve is secured by tightening the swivel hex nut in a clockwise direction. The recommended torque is 50 to 70 inch-pounds.

Secure the pressure source, remove the air/nitrogen pressure charging chuck, and replace the valve cap. The valve cap is installed finger-tight.

NOTE: Almost all systems have specific servicing instructions; therefore, consult the Maintenance Instructions Manual prior to servicing any system. Landing gear struts, hydraulic accumulators, reservoirs, etc., must be service by qualified personnel within the AMH rating. AME personnel are only responsible for servicing equipment or systems that are maintained by their rating or equipment and systems which they have been qualified to service as a result of their assignment as a qualified plane captain.

Servicing Air Storage Bottles

Some aircraft use nitrogen/air storage bottles for the various emergency operations which are necessary for the safe operation of the aircraft and the safety of the crew. Air storage bottles are used for such functions as emergency brakes, emergency landing gear extension, and emergency canopy operation.

Some aircraft have a pneumatic system which will maintain the required pressure in these bottles in flight. However, most of these pneumatic systems require servicing on the ground with an external source of high-pressure air or nitrogen prior to each flight.

Air storage bottles are serviced in the same manner as accumulators. Most air bottles have an air filler valve and a pressure gage. These systems generally require higher servicing pressure than accumulators. In most cases, the high-pressure compressor or other special equipment such as the nitrogen booster must be used to obtain these higher pressures.

The canopy bungee cylinder on the A-4E aircraft is an example of a storage unit which requires pneumatic servicing. This unit aids in opening and closing the canopy and in emergencies removes the canopy from the aircraft. The Maintenance Instructions Manual specifies the use of high-pressure nitrogen in this unit; therefore, the nitrogen booster is used in servicing. (See fig. 10-18.)

The nitrogen booster shown in figure 10-18 has one 1,800 psi bottle of nitrogen enclosed behind the control panel an utilizes a source of low-pressure air to operate the booster or pump which is used to boost the nitrogen to the required pressure.

Since gases expand with heat and contract, when cooled, air storage bottles are usually filled to a given pressure at ambient temperature. A graph similar to that shown in figure 10-18 is usually mounted on a plate or decal on or near the bottle or air filler valve. If the instructions plate is missing or not readable the information may be found in the General Information and Servicing section of the applicable Maintenance Instructions Manual.

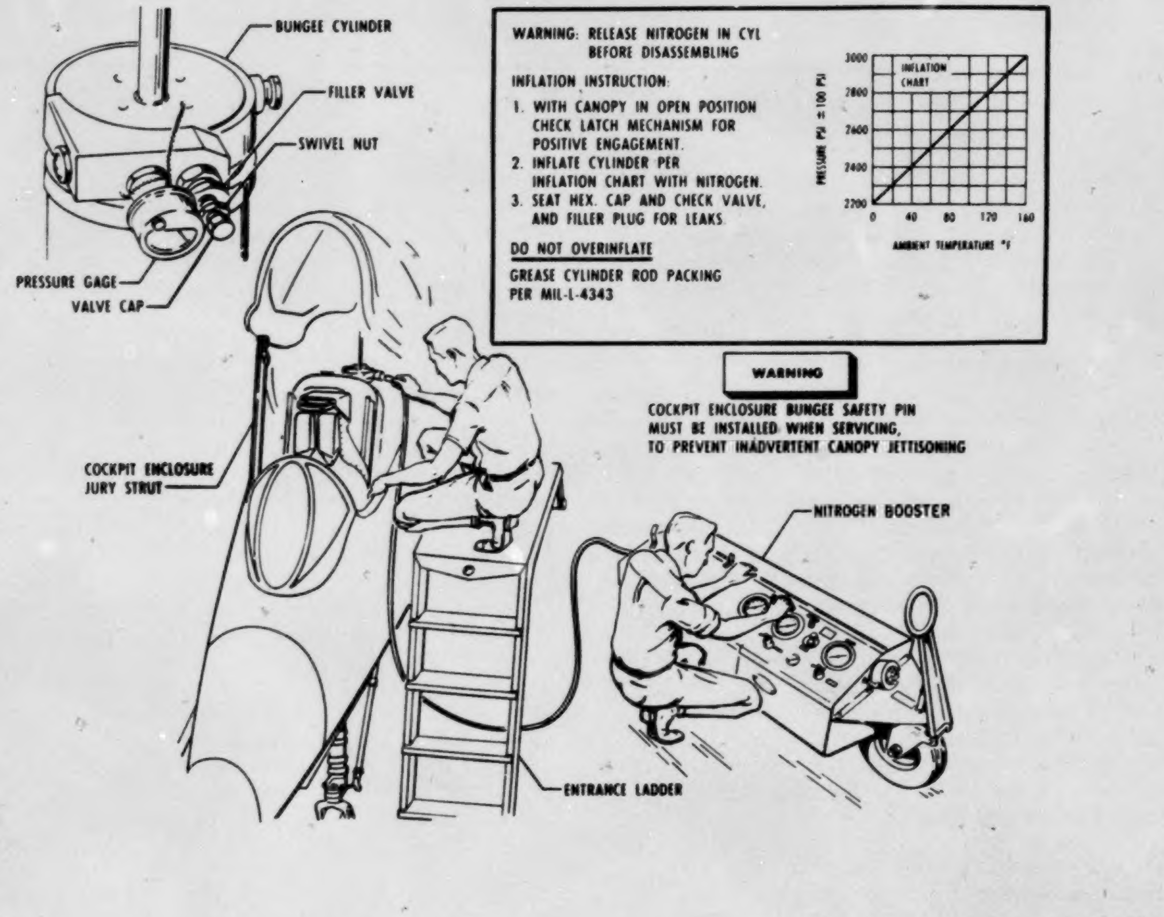
Pressure should be added to air storage bottles slowly in order not to build up heat from rapid transfer. Care should be taken to insure that air storage bottles are not overinflated.

Inflation of Tires

Correct air pressure must be maintained to receive satisfactory service from aircraft tires. Air pressure must be checked daily with an accurate gage. Tires must be inflated to the pressures specified for the type of operation (ashore or afloat) and the gross weight of the particular type aircraft. Tire inflation data is usually found as illustrated in figure 10-19. In case the plate is missing from the aircraft, this data may also be found in the General Information and servicing section of the applicable Maintenance Instructions Manual.

Overinflation reduces the contact area of the tire, causing it to wear faster at the tread center. Failure due to carcass ruptures and breaks in the tire cords which result from contacts with foreign objects are usually caused by overinflation.

Underinflation increases contact area and causes the tire to wear rapidly and unevenly at the outer edges of the tread. An underinflated tire flexes excessively and develops high temperatures which weaken the tire cords. An underinflated tire may also slip on the wheel when landing and shear off the valve stem.


BUNGEE CYLINDER
FILLER VALVE
SWIVEL NUT
PRESSURE GAGE
VALVE CAP
COCKPIT ENCLOSURE JURY STRUT
NITROGEN BOOSTER
ENTRANCE LADDER
INFLATION CHART
PRESSURE PSI ± 100 PSI
3000
2800
2600
2400
2200
0
40
80
120
160
AMBIENT TEMPERATURE °F

WARNING: RELEASE NITROGEN IN CYL BEFORE DISASSEMBLING

INFLATION INSTRUCTION:

1. WITH CANOPY IN OPEN POSITION CHECK LATCH MECHANISM FOR POSITIVE ENGAGEMENT.
2. INFLATE CYLINDER PER INFLATION CHART WITH NITROGEN.
3. SEAT HEX. CAP AND CHECK VALVE, AND FILLER PLUG FOR LEAKS.

DO NOT OVERINFLATE

GREASE CYLINDER ROD PACKING PER MIL-L-4343

WARNING

COCKPIT ENCLOSURE BUNGEE SAFETY PIN MUST BE INSTALLED WHEN SERVICING, TO PREVENT INADVERTENT CANOPY JETTISONING

AM. 211

Figure 10-18.—Servicing the A-4E canopy bungee system.

To determine the proper inflation pressure, check the inflation chart. For example, using the chart in figure 10-19, if the gross weight of the aircraft is 20,000 pounds, the correct tire pressure for that aircraft when shore based would be 310 psi. When carrier based, the pressure would be maintained at 350 psi regardless of the gross weight.

If the tire pressure is found to be low, air should be added from a regulated source. CAUTION: An unregulated high-pressure air source for tire inflation is a hazard. Tire inflation source pressure should be carefully monitored. If high-pressure cylinders such as the portable air bottle or the air or nitrogen servicing trailer are used, the regulator must be used to prevent inadvertent overinflation.

A remote inflator unit should always be used when inflating tires. The operator of this unit should always stand at right angles to the landing gear axle, directly in front or in the rear of the tire. The operator should also stand at the full length of the inflator unit hose. This will prevent the operator from being struck by pieces of the wheel in case of failure.

CAUTION: When an aircraft wheel is to be removed from the aircraft, the air must be removed prior to removing the wheel. This precaution must be taken because of the possibility that the bolts in split type wheels might have been sheared from landing, thus causing the wheel halves to separate when the axle nut is removed. In the past, several people have been killed by their failure to remove the air from the tire before removing the axle nut.

AIRCRAFT LUBRICANTS AND LUBRICATION

The proper lubrication of modern high-speed, high-altitude aircraft is an extremetly important part of line maintenance. All maintenance personnel should be familiar with the various types of lubricants, their specific use, and the method and frequency of application.

LUBRICANTS

Lubricants are substances which are spread in a thin coat or film over surfaces which move across each other to reduce friction and wear between the surfaces. Lubricants also help to dissipate heat generated in bearings, prevent corrosive attack on bearing surfaces, and protect the bearings from foreign particle contamination. If adequate lubrication is not provided as specified in the various inspection requirements and Maintenance Requirements Manuals, bearing failure, binding of mechanisms, etc. can be expected. Lubricants are greases, oils, or compounds, and they come in a liquid or solid form. A compound lubricant consists of grease mixed with graphite, white lead, or other substances for a specific purpose.

Proper lubrication is essential to the successful operation of the aircraft's moving parts. Greases and oils are the two most common lubricants with dry film lubricants in limited use.

Greases used in roller element type bearings generally consist of an intimate dispersion of a thickening agent with oil. The oil can be a petroleum derivative (mineral) or chemical synthesis (synthetic) depending on the expected temperatures encountered in its application. The thickener keeps the oil in suspension and acts as a reservoir. As the moving parts come in contact with the grease, oil adheres to the bearing surfaces. Bleeding of the oil from the grease takes place gradually so that a small quantity of oil sufficient for proper operation is continuously supplied. The oil that is picked up by the moving parts of the bearing gradually deteriorates from the effects of oxidation, is lost by evaporation, or is thrown free by centrifugal force. As this process continues, the oil content of the grease is depleted and the lubricant will no longer give adequate service. It is for this reason that during lubrication all the old lubricant should be forced from each lubrication point until new lubricant appears.

Types of Lubricants

It is impractical to cover each type of lubricant approved by NavAirSysCom and in use at the present time. The types of lubricants recommended for various aircraft applications will vary with each type of aircraft to some degree depending on the aircraft manufacturer. Some of the more common types are discussed in the following paragraphs.

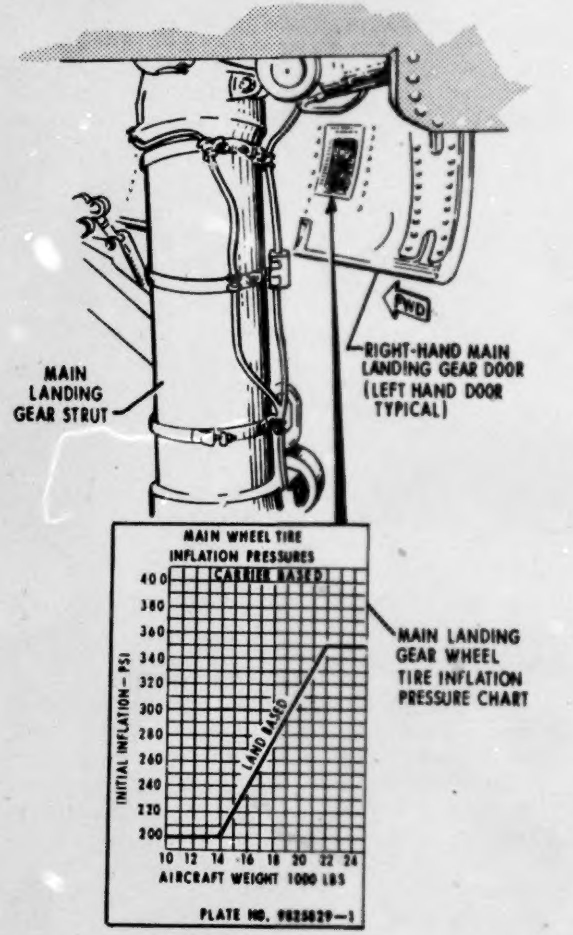
AIRCRAFT GENERAL PURPOSE GREASE, WIDE TEMPERATURE RANGE.—MIL-G-81322 is used in the lubrication of aircraft accessories operating at high speeds over a wide temperature range (-65° to + 350° F). It was specifically designed for use in aircraft wheel bearings, antifriction bearings, gear boxes, and plain bearing applications that fall within the operating temperature range. It is available in 1-pound cans, 35-pound pails, and 14-ounce cartridges.

NOTE: MIL-G-81322 grease is not compactible with other lubricants. If it is to be used as a recommended substitute for another type of grease, insure that all traces of the original grease are removed first.

AIRCRAFT GENERAL PURPOSE GREASE.—MIL-G-7711 is designated for use in gear boxes, anti-friction bearings, and plan bearings where operation at both low and high temperatures (-40° to + 250° F) may be required.

AIRCRAFT AND INSTRUMENT GREASE, GEAR AND ACTUATOR SCREW.—MIL-G-23827 is intended for use in ball, roller, and needle bearings; sliding and rolling surfaces of instruments, cameras, electronic gear, and aircraft control surfaces; aircraft gears, actuator screw mechanisms, and other equipment requiring a lubricant with a high load carrying capacity over a temperature range between -100° to + 250°F. It can withstand temperatures up to 300° F for short periods of time.

NOTE: MIL-G-23827 supersedes MIL-G-3278, 7118, and 7421, which are still listed in many Maintenance Instructions Manuals as of this writing. MIL-G-23827 grease should not be used in contact with rubber and painted or acrylic surfaces as it will damage these surfaces. Bearings should be clean and free of other greases, oil, and water before application. While


MAIN LANDING GEAR STRUT
RIGHT-HAND MAIN LANDING GEAR DOOR (LEFT HAND DOOR TYPICAL)
FWD
MAIN WHEEL TIRE INFLATION PRESSURES
CARRIER BASED
LAND BASED
INITIAL INFLATION—PSI
400
380
360
340
320
300
280
260
240
220
200
10
12
14
16
18
20
22
24
AIRCRAFT WEIGHT 1000 LBS
PLATE NO. 9825829—1
MAIN LANDING GEAR WHEEL TIRE INFLATION PRESSURE CHART

AM. 212

Figure 10-19.—Tire inflation chart.

this is true in lubricating all bearings it is especially important when applying MIL-G-23827 grease.

PNEUMATIC SYSTEM GREASE.—MIL-G-4343B is intended for use as a lubricant between rubber and metal parts of pneumatic systems. It is also used on pressurized cabin bulk-head grommets and other mechanisms where rubber-to-metal lubrication is required.

MOLYBDENUM DISULFIDE GREASE.—MIL-G-21146C is intended for use as a lubricant for accessory splines, heavy loaded sliding surfaces, and for antifriction bearings carrying high loads and operating through wide temperature ranges. The molybdenum disulfide affords better than average reliability in preventing or delaying seizure in the event of marginal or inadequate lubrication.

AIRCRAFT BALL AND ROLLER BEARING GREASE.—MIL-G-25013D is intended for use in antifriction bearings exposed to low torque at temperatures as low as -100° F and will provide adequate lubrication for extended periods at temperatures as high as + 450°F.

NOTE: MIL-G-25013D supersedes MIL-G-27343A which may appear in some Maintenance Instructions Manuals and (03) Overhaul Manuals.

GENERAL PURPOSE GREASE.—MIL-G-23549A is a molybdenum disulfide grease intended for general purpose use on automotive and ground support equipment that could be exposed to high-pressure steam, salt water, high load, and high temperatures and low speed. It is not generally designed for aircraft use.

NOTE: In all cases utilize the type of lubricant designated in the General Information and Servicing volume of the applicable Maintenance Instructions Manual and the applicable Maintenance Requirements Cards.

GENERAL PURPOSE LUBRICATING OIL.—Oil procured under Specification MIL-L-7870, is used primarily for general squirt can lubrication. It is used on canopy tracks, aileron and trim tab hinges, and many other locations on the aircraft where a light, low-temperature, corrosion-preventive lubricant is required.

Federal Specification VV-L-800 is a preservative type lubricating oil which contains corrosion and oxidation inhibitors and water-displacing agents. This type lubricating oil is specified for use on most aircraft as a lubricant for all piano hinges.

METHODS OF APPLICATION

The different types of lubricants can be applied by any one of the following methods, as applicable.

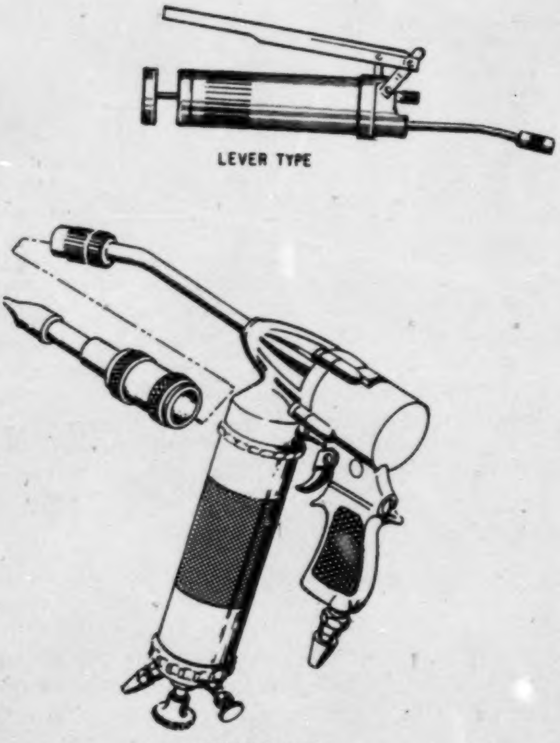
Grease Guns

Grease guns are used for general heavy-duty lubrication. There are numerous types and sizes of grease guns available for different purposes. The lever type and pressure type guns are two of the many types.

Grease guns are used in conjunction with "zerk" fittings for lubrication of landing gear actuators and other similar components. The operation of the zerk fitting is similar to the one-way check valves found in hydraulic systems. When the grease gun is removed, a spring-loaded ball check is seated, preventing the grease in the unit from escaping back through the fitting.

A special flush type grease fitting is now being used on many installations to replace the old zerk type fitting. They are press fitted into the unit and require an adapter, which can be attached to both type guns.

Figure 10-20 illustrates both types of guns with the adapter. The grease guns may be equipped with a flexible hose instead of a rigid extension.



AM. 213

Figure 10-20.—Grease guns.

Oil or Squirt Can

Oil or squirt cans are used for general lubrication, using the specified oils for the component or part being lubricated. Always check to make sure the squirt can contains the proper lubricant before using it.

Hand

This method of lubrication is generally employed for packing wheel bearings.

Brush

This method of lubrication is employed when it is necessary to cover a large area with a lubricant or for coating tracks and guides.

LUBRICATION CHARTS

The lubrication requirements for each model of aircraft are given in the General Information and Servicing section of the Maintenance Instructions Manual. These instructions appear in the form of tables and charts.

A table of lubricants similar to the one illustrated in figure 10-21 lists all of the various types of lubricants to be used in lubricating the entire aircraft. Additional information, such as frequency symbols, application symbols, specification numbers and symbols, and the NATO symbol, is provided on this table.

The lubrication of most new type aircraft is performed using the applicable Maintenance Requirements Card as a guide. Lubrication is required at the intervals specified on the various Maintenance Requirement Card sets (Preflight, Daily, Postflight, Special (7 day, 14 day, etc.), Conditional, and Calendar). Figure 10-22 illustrates one of the lubrication cards used in accomplishing the 105 day special inspection on the F-4 aircraft. The card shows the types of lubricants required, number of lubrication points, an illustration of the unit to be lubricated, and the method of application.

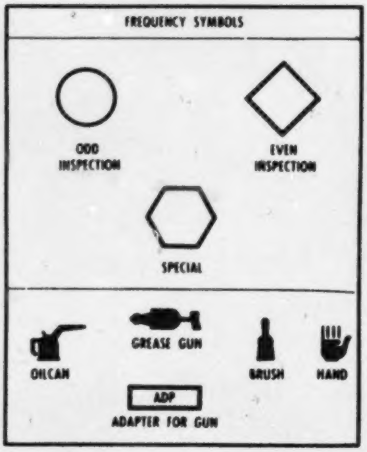
NOTE: The frequency symbols used in figure 10-21 are not necessarily standard for all aircraft. In reading the lubrication chart for a particular aircraft, always refer to the applicable table of lubricants for the correct interpretation of all symbols.

GENERAL LUBRICATION PROCEDURES

Prior to lubricating any components or parts, all foreign matter should be removed

TABLE OF LUBRICANTS

MILITARY SYMBOL	NATO SYMBOL	NOMENCLATURE	SPECIFICATION NUMBER
NONE		ANTISEIZE COMPOUND, FEL-PRO C-5 FELT PRODUCTS CO., CHICAGO, ILL.	
CT		CORROSION PREVENTIVE COMPOUND, SOLVENT CUTBACK, COLD APPLICATION	MIL-C-16173, GRADE 3 AND 4
BRW		GREASE, AIRCRAFT, BALL AND ROLLER BEARING, WIDE TEMPERATURE RANGE	MIL-G-81322A
GIA	G-354	GREASE, AIRCRAFT AND INSTRUMENT GEAR AND ACTUATOR SCREW	MIL-G-23827
GGA	G-355	GREASE, GRAPHITE, AIRCRAFT LUBRICATING	MIL-G-7187
GMD		GREASE, MOLYBDENUM DISULFIDE	MIL-G-21164
OHC	C-635	HYDRAULIC FLUID, PETROLEUM BASE, PRESERVATIVE	MIL-H-6083
GPS		LUBRICATING GREASE, PNEUMATIC SYSTEM	MIL-G-4343
OGR		LUBRICATING OIL, GEAR, PETROLEUM BASE	MIL-L-6086
OGP	O-142	LUBRICATING OIL, GENERAL PURPOSE LOW TEMPERATURE	MIL-L-7870
PL-SPECIAL		LUBRICATING OIL, GENERAL PURPOSE, PRESERVATIVE	VV-L-800
NONE		MOLYBDENUM DISULFIDE POWDER, LUBRICANT	MIL-M-7866



AM. 214

Figure 10-21.—Lubrication chart.

from joints, fittings, and bearing surfaces. A clean soft cloth saturated with a cleaning solvent can be used for this purpose. The lubricant should be applied sparingly to prevent accumulation of dust, dirt, and other foreign matter.

When applying lubricants through pressure type fittings with a grease gun, make sure the lubricant has emerged around the bushing. If no grease appears around the bushing, check the fitting and grease gun for proper operation. Always make sure the grease gun is properly attached to the fitting and wipe up all excess grease when finished. If the new flush type fitting is being used, the grease gun must be equipped with the flush type adapter, and it must be held perpedicular to the surface of the fitting when greasing, if possible.

NOTE: Some of the high-speed mechanisms on modern aircraft are critical as to the lubricant required. If the exact lubricant specified in the Maintenance Instructions Manual cannot be obtained, and there is no substitute listed, a substitute should be requested from higher authority, and only their recommended substitution should be used.

Clean up all spilled or excess oil or grease after the aircraft is lubricated. Never allow oil or grease to come in contact with oxygen equipment. Some types of synthetic compounds are harmful to rubber, neoprene, and electrical material. They will also soften paint and should be removed as soon as possible with a clean cloth.

MAINTENANCE DOCUMENTATION

The numerous maintenance tasks that are performed on the line are never complete until the necessary maintenance documentation (MAF's, SAF's, etc.) have been completed and turned in for processing. Throughout this manual various examples of this documentation have been shown with their intended use.

In order to achieve the highest possible state of aircraft readiness and reliability at the lowest cost in manpower, money, and material, maintenance documentation cannot be overstressed. Detailed instructions on the use and preparation of the various maintenance document forms are provided in Military Requirements for Petty Officer 3 & 2, NavPers 10056 (Series) and OpNav Instruction 4790.2 (Series).

AIRCRAFT JACKING

The AME should be familiar with the jacking of an aircraft in order to be able to assist in performing routine maintenance. Since jacking procedures and safety precautions vary for different types of aircraft, only general jacking procedures and precautions are discussed in this chapter. Consult the applicable Maintenance Instructions Manual (General Information and Servicing section) for specific jacking procedures.

CARD 46	TIME 01:05	RTG. NO. AME 1	SPECIAL 105 DAYS	EJECTION SEAT LUBRICATION	ELEC PWR NA HYD PWR NA
TASK MIN.	WORK AREA	MOS. NO. 6062 1	PUBLICATION NUMBER NAVAIR 01-245FDD-6-3	CARD SET DATE 1 JUNE 1971	CHANGE NO.

SPECIAL TOOLS/EQUIPMENT

Brush	1 Inch
Oiler, Hand	77335-1105

CONSUMABLES/REPLACEMENT PARTS

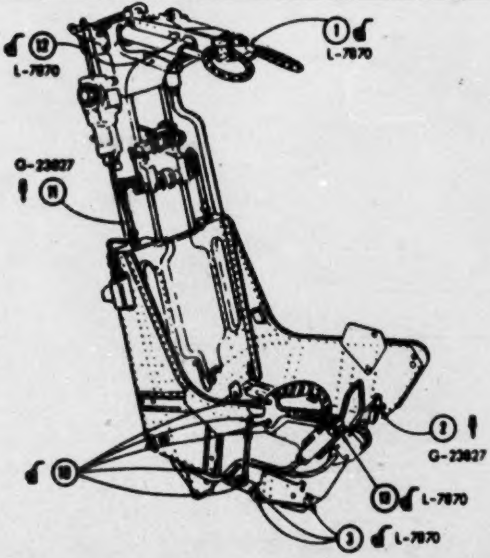
Grease, Aircraft and Instrument	MIL-G-23827
Oil, General Purpose	MIL-L-7870

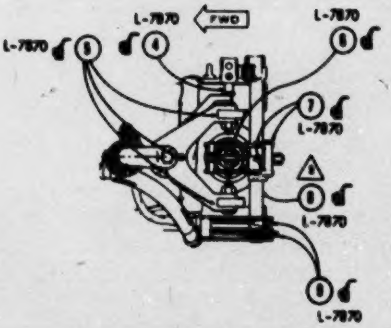
NOTE: Clean all lubrication points and surfaces prior to application of lubricant; wipe off excess lubrication upon completion.

30.0 14,15 1. Lubricate fwd and aft ejection seats (top and right side) as follows:

ITEM	NOMENCLATURE	NO. OF POINTS	SPECIFICATION
1.	Face Curtain Handle	1	MIL-L-7870
2.	Leg Restraint Locking Plunger	1	MIL-G-23827

CARD 46.2	PUBLICATION NUMBER NAVAIR 01-245FDD-6-3	EJECTION SEAT	CHANGE NO.





NOTE

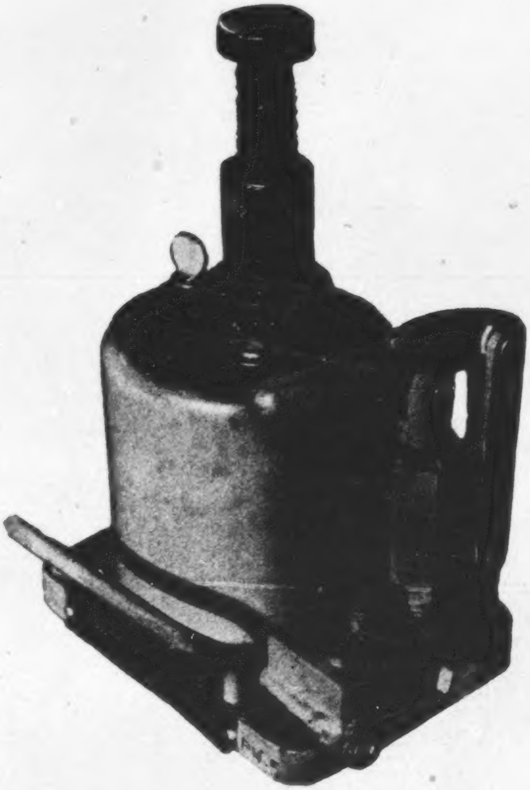
LUBRICATION SHOULD BE APPLIED SPARINGLY AND CARE MUST BE EXERCISED TO PROTECT CLOTH GOODS AND INITIATORS DURING APPLICATION.

AM. 1212

Figure 10-22.—Maintenance Requirements Card for lubricating an aircraft.

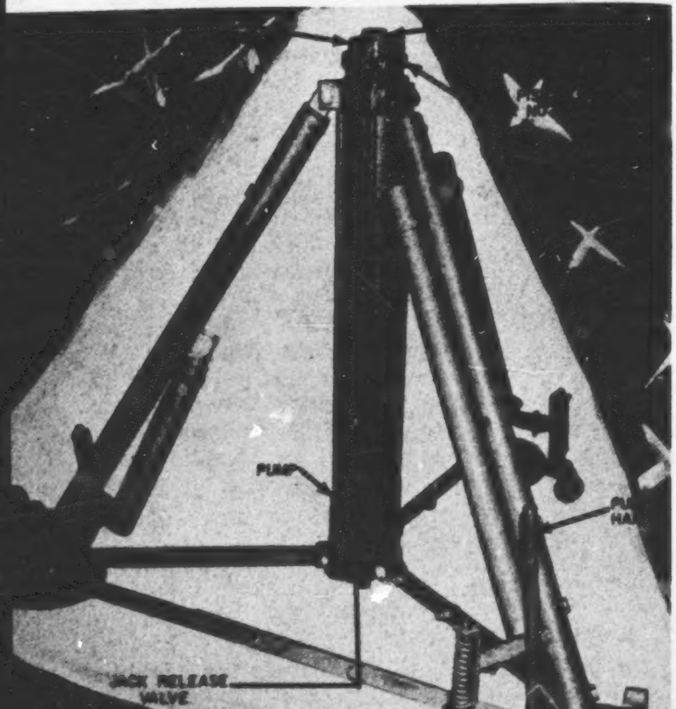
The aircraft to be jacked must be located in a level position, well protected from the wind. A hangar should be used if at all possible. The Maintenance Instructions Manual for the aircraft being jacked should be checked for the location of the jacking points. These jacking points are usually located in relation to the aircraft center of gravity so that the aircraft will be well balanced on the jacks. However, there are some exceptions to this. On some aircraft it may be necessary to add weight to the nose or tail to achieve a safe balance. Sandbags are usually used for this purpose.

Tripod jacks similar to the one shown in figure 10-23 are used when the complete aircraft is to be jacked. A smaller jack similar to the one shown in figure 10-24 is used when only one wheel is to be raised. The jacks used for jacking aircraft must be maintained in good condition; a leaking or damaged jack must never be used. Also each jack has a maximum capacity, which must never be exceeded.



AM. 217

Figure 10-24.—Single-base jack.



AM. 216

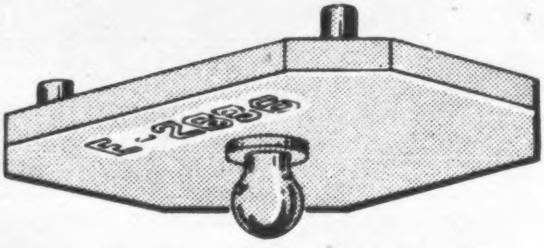
Figure 10-23.—Tripod jack.

PROCEDURE FOR JACKING COMPLETE AIRCRAFT

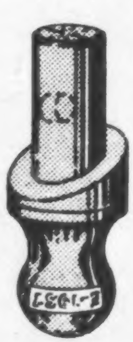
Prior to the actual jacking of the aircraft, an overall survey of the complete situation should be made to determine if any hazards to the aircraft or personnel exist. Tripod jacks of the appropriate size for the aircraft being jacked should be placed under the aircraft jacking points and perfectly centered to prevent them from cocking when the aircraft is raised. The legs of the jacks should be checked to see that they will not interfere with the operations to be performed, such as retracting of the landing gear, after the aircraft is jacked.

Jack pads, which are used as adapters between the jacks and the aircraft jacking points, are carefully installed and must fit perfectly. The jacks should be extended until they contact the jack pads. A final check for alignment of the jacks should be made before the aircraft is raised, as most accidents that occur during jacking are the result of misaligned jacks. Figure 10-25 illustrates two typical types of jack pads.

When the aircraft is ready to be raised, a man shculd be stationed at each jack. The jacks should be operated simultaneously to keep the aircraft as level as possible and to avoid overloading any of the jacks. This can be accomplished by having the crew leader stand in front of the aircraft and give instructions to the men operating the jacks. Figure 10-26 illustrates an aircraft being jacked.



WING JACK PAD ASSEMBLY



FORWARD JACK FITTING

AM. 218

Figure 10-25.—Jack pads.

CAUTION: On many jacks the piston can be raised beyond the safety point; therefore, never raise an aircraft any higher than is necessary to accomplish the job at hand.

CAUTION: Avoid overextension of the threaded extension. While its compression strength is equal to the compression strength of the jack as a whole, its thin cross-sectional area makes it particularly susceptible to bending and breaking under side loads, especially when near its full extension.

NOTE: While jacking, the piston locknuts (fig. 10-23) should be moved down as the piston is raised. This will prevent the jack from collapsing in the event of a sudden loss of fluid. When jacking is complete, the locknuts should be locked snugly against the jack body.

The area around the aircraft should be secured while the aircraft is on jacks. Climbing on the aircraft should be held to an absolute minimum, and no violent movements should be made by persons who are required to go aboard. Safety jacks or cradles designed to support the aircraft while on jacks should be put in place as soon as possible, particularly if the aircraft is to remain jacked for any length of time.

Jacking procedures aboard ship require an extra measure of caution because of ship movements. Permission to jack the aircraft must be given by the activity's maintenance control. No jacking will be authorized unless the weather is calm and the ship is expected to be on a straight course during the time the aircraft will be on jacks.

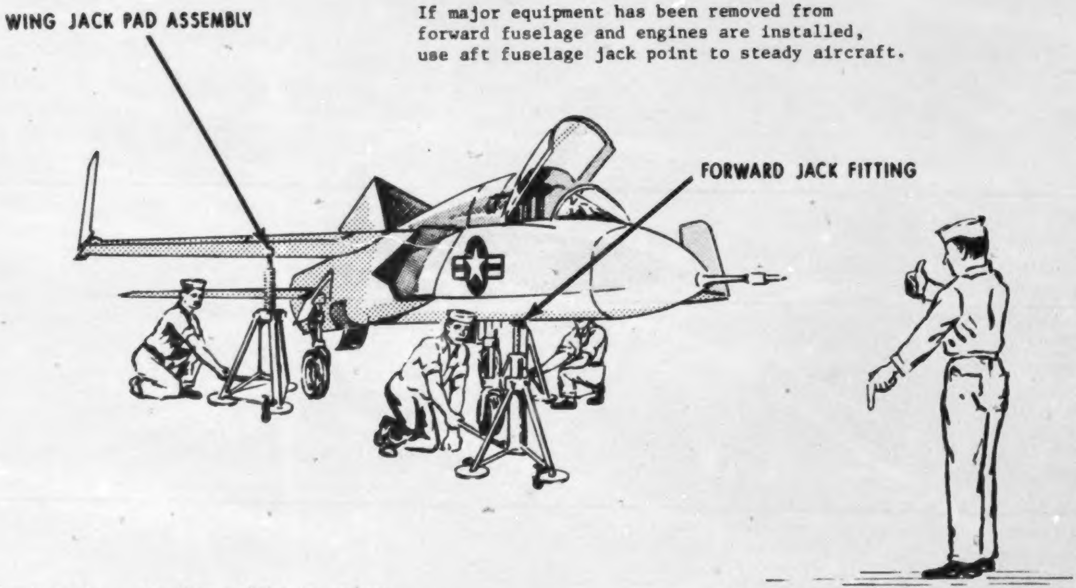
Figure 10-27 illustrates the shipboard jacking arrangement for the A-4E aircraft. Additional TD-1 tiedown chains may be utilized to anchor the jacks in position as a further measure of safety. Additional tiedown chains may also be added to landing gear and other tiedown attach points if drop checking operations permit.

PROCEDURE FOR JACKING ONE WHEEL

There are many different types of jacks used for jacking one wheel of an aircraft to change a tire or grease wheel bearings. They range in tonnage from 3 to 50 tons. The specific maintenance manual must be consulted for the recommended jack. Before the wheel is raised, the remaining wheels must be chocked fore and aft to prevent movement of the aircraft. If the aircraft

NOTE

If major equipment has been removed from forward fuselage and engines are installed, use aft fuselage jack point to steady aircraft.



1. Defuel aircraft to landing weight to reduce structural loads.
2. Inflate landing gear struts. See Warning note.
3. Install forward fuselage and wing jack pads.
4. Jack wing and forward fuselage points evenly.
5. When aircraft is jacked to desired height, set ram safety nuts.

WARNING

- Lower aft fuselage jack before any other jacks to prevent structural damage.
- Do not use more than 1000 PSI air source when inflating struts.

AM.219

Figure 10-26.—Jacking complete aircraft.

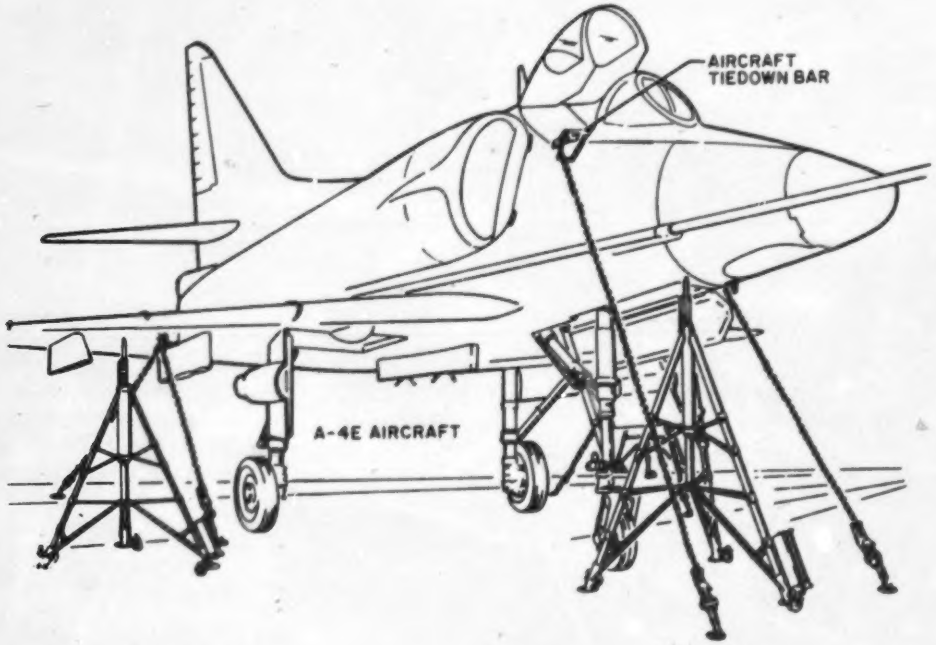
is equipped with a tailwheel, it must be locked. The wheel should be raised only high enough to clear the deck. Figure 10-28 shows a nosewheel being raised.

MISCELLANEOUS GROUND HANDLING EQUIPMENT

When assigned to the line division, the AMEAN or AME3 may be required to assist in the starting of aircraft engines or ground testing of various items of aicraft equipment. To do this it will be necessary to know how to operate equipment such as mobile electric powerplants and gas turbine compressors. Special training and in some cases licensing is required of operators of such equipment.

MOBILE ELECTRIC POWERPLANTS (MEPP)

There are many different types of mobile electric powerplants in common use. Some types are self-propelled and others must be pushed or towed to the aircraft which is to be serviced. The NC-5, NC-7, NC-10/10a, NC-12 and 12A, and the Mobile Motor Generator (MMG) units are still in use throughout the Navy and possess similar controls and operating features. Since special training is required and provided by



AM. 1213

Figure 10-27.—Shipboard jacking arrangement—A-4E.

ground support equipment personnel to insure that such equipment is operated only by fully qualified operators, only brief descriptive coverage is provided in this manual on the NC-5 and the NC-7B.

Operation and servicing instructions for the various types of mobile electric powerplants can be located by referring to the applicable NavAir 19 (Series) Operating and Servicing Manual for the specific model equipment as listed in the NavAir Publications Index, NavAir 00-500A.

NC-5 Power Unit

The NC-5 is a self-propelled electric power unit. It may be driven from place to place in the same manner as any other motor vehicle.

It has provisions for delivering three different kinds of power—constant voltage variable current d-c electrical power for starting jet aircraft engines; constant voltage d-c power for starting reciprocating aircraft engines or jet aircraft engines in aircraft having a single bus type electrical system; and 115/200-volt, 3-phase, 400-Hz alternating current for checking and operating a-c equipment, each through a separate cable.

The power cables are plugged into the aircraft electrical system at an external power receptacle. Figure 10-29 shows the NC-5 and the external power receptacle similar to that found on most new aircraft. Aircraft with this type external power receptacle require the use of only one type power, 115/200-volt, 400-Hz alternating current (a.c.).

Some aircraft require the use of 28-volt direct current (d.c.) for starting reciprocating engines. Figure 10-30 shows the external power receptacle used on an aircraft which requires both 400-Hz a.c. and 28-volt d.c. NOTE: The shape of the plug and the spacing of the pins in the receptacle make it impossible to plug the wrong type cable into the aircraft.

When applying electrical power to an aircraft, park the NC-5 in a position so that the cable will reach without causing a load on the external power receptacle. The weight of the cable might cause damage to the structure around the receptacle.

Insure that the power unit exhaust is not near the skin of the aircraft. The heat from the exhaust could cause damage to the skin or the paint finish.

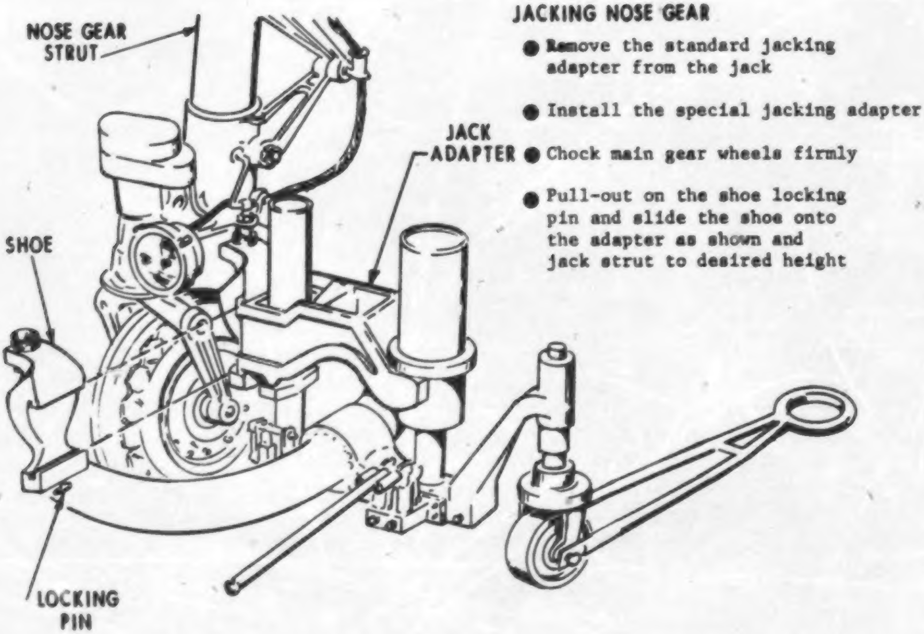
Servicing an aircraft with an NC-5 should always be a two-man job. The driver should remain at the wheel and operate the generator drive unit and the throttle. The second man should operate the unit's electrical system and plug the power cables into the aircraft.

Before engaging the generator drive unit, make sure that the transmission is in neutral. Much damage is caused throughout the Navy by carelessness in the operation of mobile electric power units. No one should attempt to operate any type of mobile electrical equipment unless he is a qualified operator. NOTE: Ground support equipment schools are being operated at all naval air stations to train operators of units such as the NC-5. All activities require a special operator's permit for the operators of these units.

After completing the turnup or checkout of equipment, the power cable should be removed from the external power receptacle and stowed in the container which is provided on the unit. Many times a year aircraft are damaged by careless NC-5 operators driving off from the aircraft with the cable still plugged in. Care should be taken to insure that the cable is not dragged on the taxi way behind the power unit. Dragging severely damages the cable, and cables are quite expensive. Before driving the unit away from the aircraft, check to insure that the generator drive unit is disengaged.

NC-7 Electric Power Unit

The NC-7 shown in figure 10-31 is powered by a V-8 gasoline engine and contains two d-c generators, an a-c generator, a control console

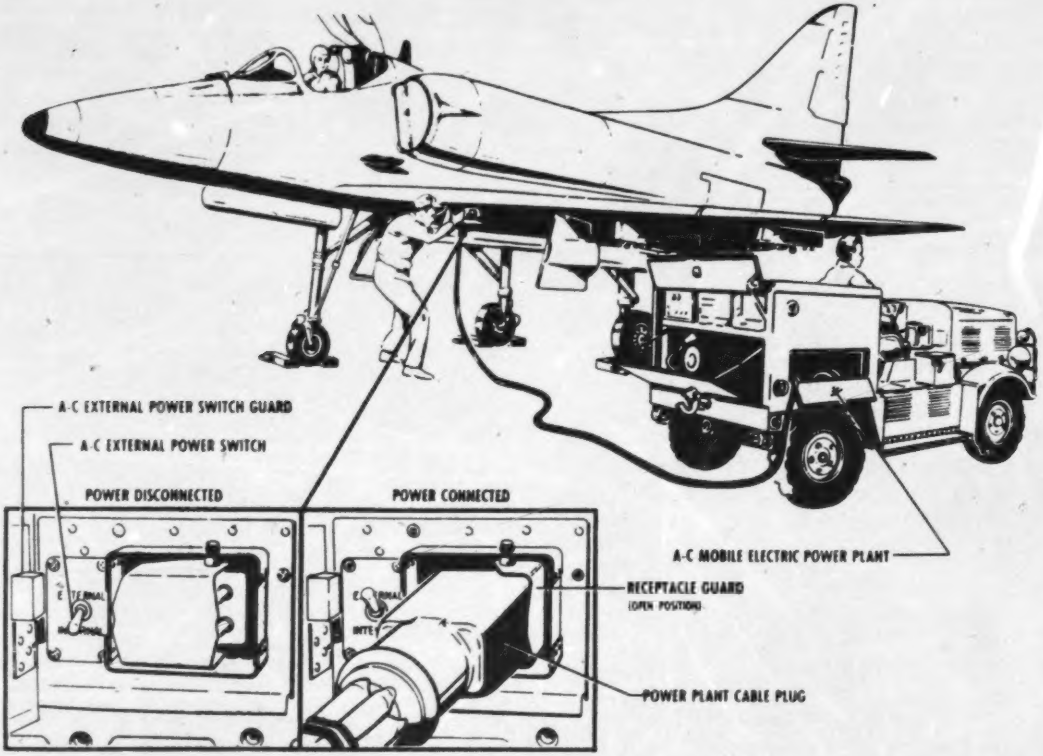


JACKING NOSE GEAR

- ● Remove the standard jacking adapter from the jack
- ● Install the special jacking adapter
- ● Chock main gear wheels firmly
- ● Pull-out on the shoe locking pin and slide the shoe onto the adapter as shown and jack strut to desired height

AM. 220

Figure 10-28.—Jacking one wheel.


A-C EXTERNAL POWER SWITCH GUARD
A-C EXTERNAL POWER SWITCH
POWER DISCONNECTED
POWER CONNECTED
A-C MOBILE ELECTRIC POWER PLANT
RECEPTACLE GUARD
(OPEN POSITION)
POWER PLANT CABLE PLUG

AM. 221

Figure 10-29.—NC-5 mobile electric power unit application.

for control of the engine and both electrical systems, and a propulsion system for moving the unit under its own power. Access doors are provided for the control console, engine, battery, cable stowage, and tool compartments.

The a-c electrical power system provides 120/208-volt 3-phase, 400-Hz power for servicing aircraft a-c components. The d-c generators provide an output of 28 volts and are rated at 750 amperes continuous and 1,000 amperes intermittently. The outputs from the two d-c generators are used for jet engine starting and servicing d-c components. Also, the output from one of the d-c generators is used to power the self-propulsion system.

A hand control unit is provided on the tow bar for controlling the unit during self-propelling operations.

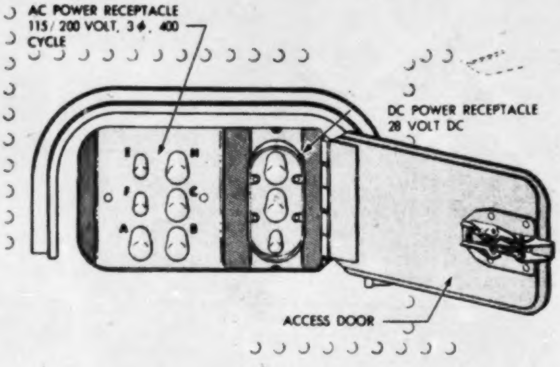
CAUTION: Do not move the power unit by means of the self-propulsion mechanism while supplying power to an aircraft. Under no condition is the unit to be used as the prime mover for towing other equipment.

The self-propelling feature should be used only when moving from one aircraft to another or from the line to the hangar and back as necessary if the distance is not too great. For greater distances the unit should be towed.

Most of the electrical power units tend to be slightly topheavy. When driving or towing such units the speed should be held to a minimum to prevent the possibility of turning the unit over. For example, the towing speed for the NC-7 is 20 MPH maximum.

GAS TURBINE COMPRESSORS

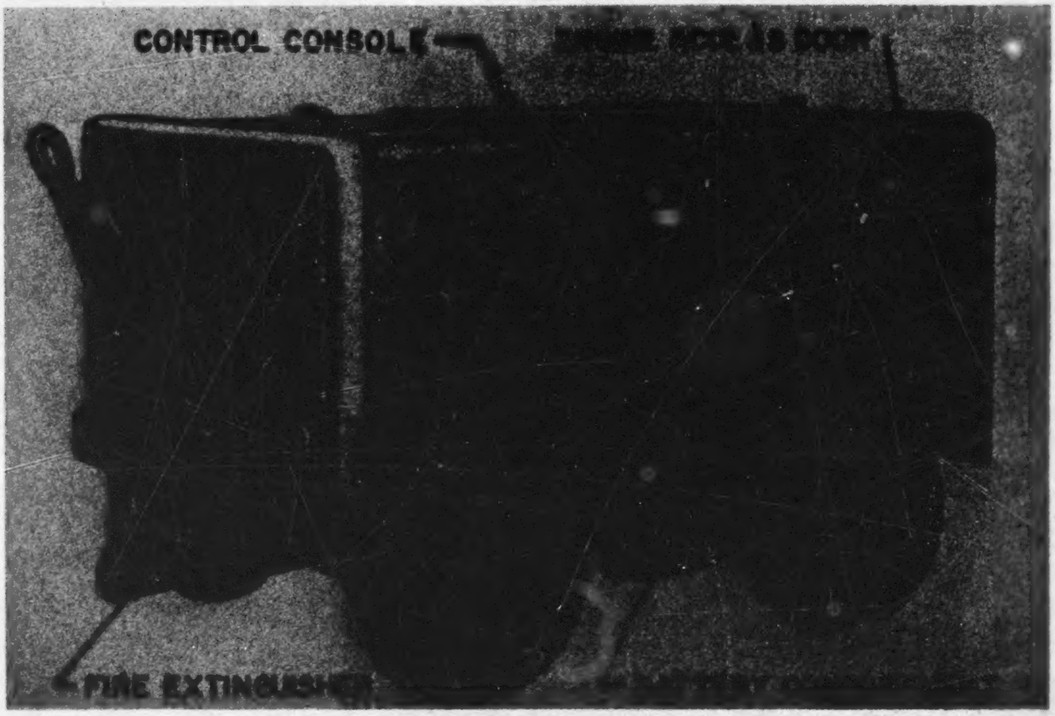
The gas turbine compressor is used to provide pneumatic power in the form of compressed


AC POWER RECEPTACLE
115/200 VOLT, 3 φ, 400 CYCLE
DC POWER RECEPTACLE
28 VOLT DC
ACCESS DOOR
E
H
F
C
A
B

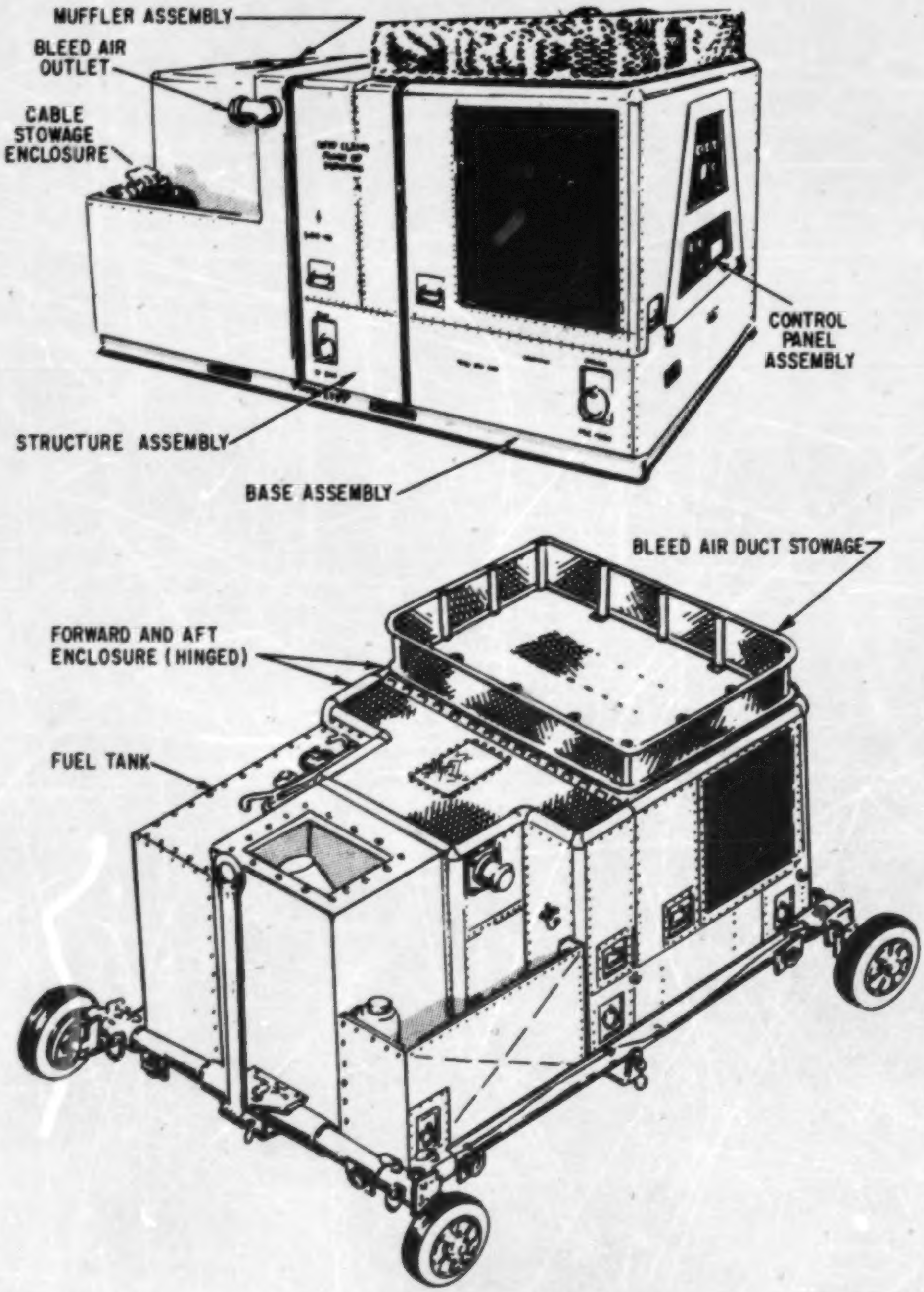
AM. 222
Figure 10-30.—External power receptacle.

bleed air for the operation of pneumatic equipment such as aircraft engine starters and air-conditioning systems, and for testing units such as the ram-air turbine. Gas turbine compressors are largely self-contained and require only an outside source of fuel and oil to maintain a constant output.

The Model NCPP-105 compressor power unit, shown in figure 10-32, is a complete, self-contained unit consisting of a flyaway assembly enclosed in a skid-mounted, weather-resistant enclosure. Some models of the NCPP-105 are mounted on trailers for ease of movement from aircraft to aircraft or place to place. The NCPP, 105 supplies compressed air, at two pressure ratios (5:1 and 3.6:1), for aircraft engine starting, and a-c and d-c electrical power for operation of aircraft a-c and d-c electrical


CONTROL CONSOLE
ENGINE ACCESS DOOR
FIRE EXTINGUISHER

AM. 1214
Figure 10-31.—Mobile Electric Powerplant (NC-7B).


MUFFLER ASSEMBLY
BLEED AIR OUTLET
CABLE STOWAGE ENCLOSURE
CONTROL PANEL ASSEMBLY
STRUCTURE ASSEMBLY
BASE ASSEMBLY
BLEED AIR DUCT STOWAGE
FORWARD AND AFT ENCLOSURE (HINGED)
FUEL TANK

AM. 903

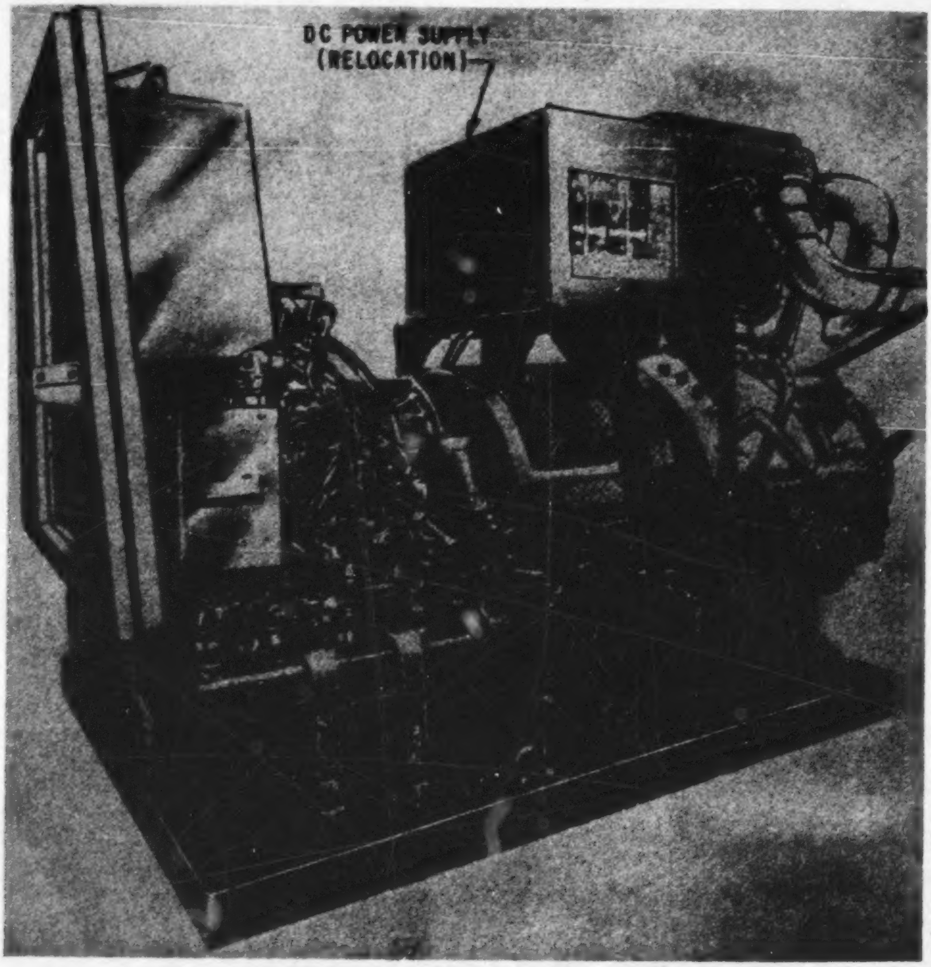
Figure 10-32.—Model NCPP-105 compressor power unit.

components. The NCPP-105 is equipped with a remote cable assembly, an a-c output cable, a d-c output cable, and a bleed air duct assembly.

The unit enclosure consists of a forward and aft enclosure (hinged together), a cable stowage enclosure, muffler assembly, fuel tank, structure assembly, and a base assembly.

The flyaway assembly, shown in figure 10-33, is normally operated while in the NCPP-105 unit enclosure, with the d-c power supply mounted in the forward enclosure. However, when it is required to transport the flyaway assembly by aircraft to a temporary location, the d-c power supply is removed and relocated on the flyaway assembly structure. The fuel line and a-c and d-c electrical output cables are disconnected, the forward and aft enclosures are lifted off the structure assembly, and the flyaway assembly is then removed from the base assembly. The flyaway assembly, with its remote cable, a-c and d-c electrical output cables, and bleed air duct assembly, upon arrival at its temporary location, can be operated by attaching it to a fuel supply.

NOTE: The NCPP-105 flyaway assembly cannot be hung as an external store and must



AM. 904

Figure 10-33.—NCPP-105 flyaway assembly.

be transported inside a transport or cargo type aircraft.

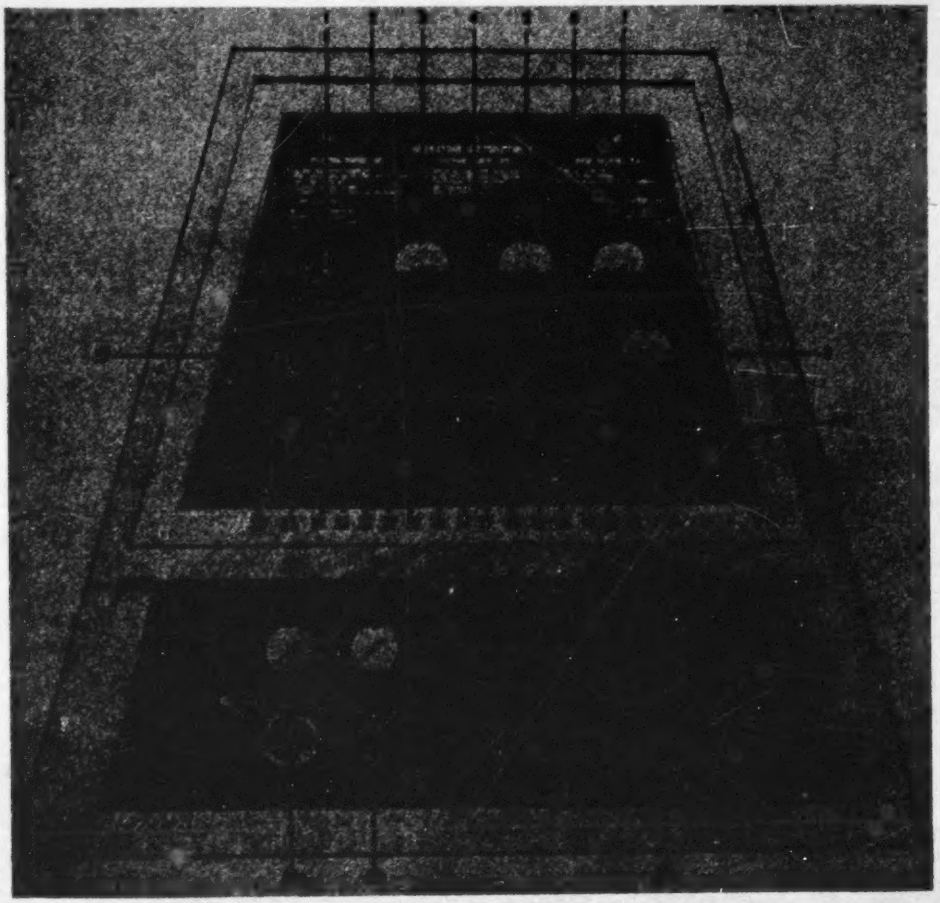
The control panel, shown in figure 10-34, is part of the flyaway assembly and is located on one end of the NCPP-105 unit. The control panel contains the operating instructions for the operation of the unit. Table 10-2 is a list of all the controls, indicators, and connectors located on the NCPP-105 control panel and should be used in conjunction with figure 10-34.

The NCPP-105 is intended for ground use only and because it is skid-mounted, should be strategically placed along the line so that it can be used to service more than one aircraft without having to be moved.

Only qualified operators should attempt to operate this type equipment. Training on this type equipment is usually included in the aviation support equipment school operated at naval air stations.

Gas turbine compressors may be damaged by trash, tools, or other foreign objects which may be left near the inlet duct. When the compressor is operating, the following precautions should be adhered to:

1. Stand clear of the air inlet. Like aircraft jet engines, these units take in large quantities of air.
2. Stand clear of the exhaust, and position the unit so that the exhaust does not strike the aircraft.



AM. 905

Figure 10-34.—NCPP-105 control panel.

Table 10-2.—Controls, indicators, and connectors—NCPP-105.

Index No. (figure 10-34)	Nomenclature	Function	Preliminary Setting or Indication
1	Indicator (M1)	Indicates engine rpm in percentage.	zero
2	Dome Assembly (DS7)	Illuminates panel.	off
3	Meter (M6)	Indicates a-c voltage.	zero
4	Dome Assembly (DS8)	Illuminates panel.	off
5	Meter (M5)	Indicates a-c amperes.	zero
6	Dome Assembly (DS9)	Illuminates panel.	off
7	Meter (M4)	Indicates d-c amperes.	zero
8	Meter (M3)	Indicates d-c voltage.	zero
9	Switch (S8)	Selects meter indication of output or battery.	OFF
10	Switch (S7)	Controls d-c power.	OFF
11	Dome Assembly (DS4)	Indicates d-c power.	off
12	Dome Assembly (DS6)	Indicates a-c overvoltage.	off
13	Dome Assembly (DS5)	Indicates a-c power.	off
14	Switch (S6)	Selects meter indication of a-c phase.	OFF
15	Dome Assembly (DS11)	Illuminates panel.	off
16	Switch (S5)	Controls and resets a-c power output.	OFF
17	Circuit Breaker (CB2)	Controls control circuit.	off
18	Circuit Breaker (CB1)	Controls power switches.	off
19	Switch (S4)	Controls panel lights.	OFF
20	Dome Assembly (DS10)	Illuminates panel.	off
21	Switch (S3)	Selects air ratio output.	OFF
22	Dome Assembly (DS2)	Indicates airflow.	off
23	Dome Assembly (DS1)	Indicates ready for power delivery.	off
24	Dome Assembly (DS3)	Indicates high oil temperature.	off
25	Switch (S2)	Controls power to starter relay.	off
26	Switch (S1)	Controls power to panel.	off
27	Indicator (M2)	Indicates engine exhaust temperature.	zero
28	Gage	Indicates engine air pressure.	zero
29	Gage	Indicates engine oil pressure.	zero
30	Circuit Breaker (CB3)	Controls power to starter.	closed
31	Circuit Breaker (CB5)	Controls d-c power to output cable.	closed
32	Receptacle (J12)	Auxiliary d-c starting and charging input.	—
*33	Receptacle (J10)	Connection for remote cable.	—
34	Plug (J11)	Provision for battery heater.	—

*Used on power units bearing Part No. 64A90-F1. For power units bearing Part No. 64A90-F1-2, connection for remote cable is located on the aft enclosure.

3. Stand clear of the plane of rotation of the turbine compressor. This area is clearly defined and marked on the equipment.

4. Do not connect or disconnect the ducting while the unit is operating.

5. Do not connect or disconnect the electrical cables while the switches are ON.

6. After servicing the aircraft, always stow the cables and ducting in the space designed for them.

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